

# Sustaining Infrastructure

A Bentley White Paper

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## Forward to 2012 Update

When this paper was first published in May 2008, its purpose was to initiate a discussion on global sustainability that embraced all of this topic's many dimensions. At the time, the concept of "green" dominated the dialogue, particularly within the infrastructure community. Undoubtedly, "green" is an important concept and a fundamental element of any strategy to improve the sustainability of the planet. However, any commitment to sustainability must include a commitment to sustaining society. This translates to a commitment to work toward providing every person on the planet with the possibility of realizing a quality of life that includes clean water, sanitation, food, access to critical services (such as education), physical security, and economic opportunity.

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While concern for our fellow human beings is perhaps reason enough to commit ourselves to the well being of all people, there is more to this than simple altruism. For many of the 4.8 billion people living below the United Nation's Human Development Index threshold for "High Human Development," particularly the 1.4 billion people living on less than \$1.25 a day, sustaining themselves and their families for another day, week, or month overwhelms any concerns about the global environment or climate change. Simply put, a true global commitment to sustainability requires a global community living with a reasonable quality of life. Thus, sustaining society and sustaining the environment go hand in hand and are completely interdependent. The corollary is that sustaining infrastructure must necessarily be about growth and not strictly about imposing limits. Sustainability requires smart growth, to be sure, but growth nonetheless. As a friend once commented, "Green is a passive state of being, but sustaining is an active and ongoing process."

Events in the four years since the initial release of this paper have demonstrated, painfully at times, that the power of nature, and the unintended consequences of human activity, far too often exceed our imaginations. Since then we've seen catastrophic earthquakes in China and Haiti, the Gulf oil spill, volcano eruptions in Iceland, flooding in Thailand, tornadoes in the Southeast U.S., drought in East Africa, and, of course, the earthquake, tsunami, and resulting nuclear disaster in Japan. These events took place in the context of the global financial crisis and recession that certainly constrains our ability to invest – publicly and privately – in solutions and strategies to address the broad topic of sustainability.

This global context does not diminish or void any of the concepts outlined in the initial version of this paper. Rather, it simply increases the urgency of the problems and issues associated with global sustainability. One observation is that these events and the simple passage of time seem to have led to a shift in the conversation about infrastructure and sustainability to include greater emphasis on adaptability and resilience. Regardless of your position (scientific or political) on climate change, its causes, or whether or not natural events are becoming more extreme, it's difficult to dispute the fact that the human and economic costs of natural events will continue to rise simply due to the fact that the global population continues to rise. This fact alone is enough to motivate a discussion on adaptation to natural events and resilient infrastructure to anticipate, absorb, accommodate, or recover from the effects of a hazardous event.

Global statistics and source references have changed over the past four years, and we've made every attempt to update this information to be as current as possible. More importantly, over the past four years our users have executed many more projects contributing to the sustainability of the planet. We've updated the references in the *Meeting the Sustainability Challenge* section to include many of these important projects.

## Introduction

The mission of Bentley Systems is to provide innovative software and services for the enterprises and professionals who design, build, and operate the world's infrastructure – sustaining the global economy and environment, for improved quality of life. Given the fundamental importance of services provided to society at large by infrastructure, this mission is certainly a worthy and significant endeavor.

However, there is now an increasingly significant level of urgency surrounding the world's infrastructure as well. There is an expanding spectrum of critical global issues in which the world's infrastructure has an important role to play. These issues include CO<sub>2</sub> emissions, climate change, the availability of clean water and sanitation, chronic hunger, unsafe bridges, earthquakes, severe weather, terrorist attacks, civil wars, coastal flooding, hazardous waste, and depletion of nonrenewable resources. The world's infrastructure – as well as the professionals around the world who design, build, and operate the world's infrastructure assets – will play a fundamentally important role in successfully addressing them.

For Bentley, these many and complex challenges fall under the broad umbrella of sustainability. This paper explains Bentley's interpretation of sustainability. It lays out our view of the role of infrastructure in creating a sustainable world; how our users are meeting these challenges today; how they can better address the challenges in the future; and how Bentley's solutions and products are positioned to support them.

## Infrastructure and Sustainability

Before detailing how Bentley users contribute to global sustainability today and will contribute in the future, it is useful to discuss the relevance of infrastructure to society at large and to creating a sustainable world.

### Infrastructure Defined

Infrastructure provides the basic facilities, services, and installations required for a community or society to function. This includes facilities – which we'll refer to as *infrastructure assets* – such as transportation and communications systems, water and power lines, structures to house public institutions including schools, post offices, and so on.

An infrastructure asset and the services it provides are typically location-specific; that is, the asset is located in a specific geographic location. It is a capital good, usually capital-intensive, providing a collection of services to the community, city, or country in which it is located.

Individual infrastructure assets often exhibit an economy of scale in terms of the incremental investment required to increase the capacity or level of service provided by the individual asset. Infrastructure *networks*, such as transportation, communications, power, and utility networks – like most networks – benefit from the network effect and can exhibit an economy of scope. The value of the services provided by the infrastructure network can increase geometrically as the nodes and the connectivity within the network increase.

Infrastructure assets generally do not provide services until they are completed. For example, a power plant or bridge that is 50 percent complete doesn't provide any services. The services aren't available until it is 100 percent complete.

Finally, infrastructure assets are long-lasting (as compared to manufactured goods), with expected useful lives of decades and perhaps centuries.

Some examples of infrastructure assets are:

- Roads
- Bridges
- Rail and transit facilities, including tracks, stations, and maintenance facilities (but not the rolling stock)
- Factories (but not the products produced by the factory)
- Communications networks
- Power generation facilities
- Residential and commercial buildings
- Campuses (including airports, government, schools, military bases, hospitals, etc.)
- Mines and metals processing facilities
- Oil and gas production facilities
- Electric and gas utilities
- Water and wastewater facilities
- Pipelines

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In many ways, infrastructure is the *interface* between people and our planet. For society to advance much beyond a very basic agrarian lifestyle requires infrastructure. Nearly all of our day-to-day interaction with the environment is mediated in some way by services provided by infrastructure. Systems to provide clean water, sanitation systems to remove human waste, schools, hospitals, roadways to distribute food, power plants to deliver electricity, factories to provide manufactured goods, and on and on – these are all forms of infrastructure.

Given the scope of infrastructure and the central importance of infrastructure to society at large, infrastructure is necessarily a central factor in achieving our sustainability objectives. Our collective quality of life, the sustainability of human society, and the sustainability of our planet are directly dependent upon the services provided by infrastructure.

## Sustainability Defined

The next important task is to define exactly what we mean by *sustainability*. The available definitions are many and, as is often the case, these definitions can easily become self-serving. They can be molded to conform to the solutions, products, or services offered by the organization offering the definition. An authoritative definition should be comprehensive and come from a source not promoting specific commercial interests.

Perhaps the first definition of sustainability, as we now consider it, was given by the report from the [Brundtland Commission](#) in 1987. In this report, sustainable development is defined as “*development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*”

Another definition comes from [The Natural Step](#), a non-profit research, education, and advisory organization. Formed in 1988, it uses a science-based framework to help individuals, organizations, and communities move toward sustainability. There are currently Natural Step chapters in 12 countries, with a number of significant Bentley users among their clients. Natural Step’s simple definition of sustainability is “*creating new ways to live and prosper while ensuring an equitable, healthy future for all people and the planet.*” It has also articulated a more [formal definition](#):

*The practice of sustainability is about creating new ways to live and prosper while ensuring an equitable, healthy future for all people and the planet. In a sustainable society, nature won’t be subject to systematically increasing:*

*Concentrations of substances extracted from the Earth’s crust;*

*Concentrations of substances produced by society;*

*Degradation by physical means;*

*And, in that society, people are not subject to conditions that systemically undermine their capacity to meet their needs.*

Thus, in a sustainable world we do not continue the accelerating depletion of nonrenewable resources, nor the consumption of renewable resources faster than the environment can regenerate them. We minimize the accumulation of waste from human activity and increase recovery and reuse of these by-products. We don't continue to systematically reduce the productive capacity of the Earth through processes such as overharvesting, soil erosion, destruction of green (CO<sub>2</sub>-absorbing) areas, and so on. At the same time, in a sustainable world, everyone can live with a quality of life in which all their basic human needs are met.

This definition is not limited to "green" initiatives or climate change or even traditional environmentalism, though they are certainly important elements of sustainability. Likewise, it is not limited to buildings alone, as it has relevance to every type of infrastructure asset. It speaks to not only being good stewards of our planet but also to meeting the needs of *all people* on the planet.

Meeting the basic human needs of everyone on the planet and the generations to follow inevitably implies development – electricity, clean water and sanitation systems, shelter, transportation, and communication systems to provide access to critical services, and so on. In short, meeting the basic human needs of all people in the world means *more and better infrastructure*.

All too often, however, these twin objectives – being good stewards of the planet while developing more infrastructure to meet the basic needs of a growing global population – are seen at odds with one another. However, the logical result of this limited view – constraining development to achieve sustainability – either denies a large portion of the developing world the opportunity to live with the quality of life we in the developed world enjoy, or requires those in the developed world to live with a significant reduction in their quality of life.

Not only are these alternatives unworkable, they can easily become *totalitarian* if carried to their logical conclusion. Meeting these twin objectives thus depends on *how* we choose to grow. It requires that we apply all of our human ingenuity, adaptability, and pragmatism to a project of *possibilities*, not *limits*. As [Thomas Friedman](#) of the *New York Times* has observed, all of our commendable efforts to reduce carbon emissions in the developed world will be "devoured" by the "exponential growth" in Asia. Only "a transformational breakthrough in the energy space" will suffice.

## Sustainability Issues

Achieving the sustainability objectives outlined here requires that we address a number of pressing issues. We've categorized those issues into interrelated categories – societal, environmental, and professional.

We'll briefly outline the scope of these issues in the following sections.

Clearly, infrastructure is fundamental to maintaining and improving quality of life on a global basis.

### *Societal Issues*

Clearly, infrastructure is fundamental to maintaining and improving quality of life on a global basis. However, it is just as clear that today's infrastructure is globally inadequate. In the developing world, for example, there is a critical need for the most basic infrastructure in order to sustain life above a minimal subsistence level. For example, according to the [World Health Organization](#), 11 percent of the world's population, as of 2010, still does not have access to the most fundamental life-sustaining resource – clean water. On one hand, the fact that this number was 24 percent in 1990 demonstrates that this isn't an intractable problem and progress can be made in addressing this most basic need. On the other hand, the fact that this still represents 780 million people without access to clean water is an indicator of the sheer size of the problem.

Even in the developed world, continually reinvesting in the existing infrastructure is critical. For example, the 2013 "[Report Card for America's Infrastructure](#)" by the American Society of Civil Engineers (ASCE) grades 15 aspects of infrastructure for adequacy and safety. The cumulative grade across all categories is a "D+," up just slightly from a "D" in previous years. In the report, the ASCE estimates that overcoming the "infrastructure deficit" – the shortfall in terms of minimum standards of adequacy, safety, and security – will require an investment of \$3.6 trillion through 2020. In 2005, the estimate was a five-year investment of \$1.6 trillion. Clearly, things aren't getting better.

Infrastructure is also fundamental to mitigating the effects of extreme events, both natural and man-made. This is particularly important given the continuing growth of the global population and the global patterns of human migration. By 2011, half of the world's 7 billion people were living in [urban areas](#). This means 3.5 billion urban dwellers today, [growing to 6.5 billion by 2050](#).

This increasing density of global population also increases the vulnerability to natural or man-made disasters, since the impact of each severe event in an urban area, in terms of both human lives and cost, will continue to rise. This vulnerability is further compounded by the fact that many of the world's largest urban areas are located near the seacoasts, which are susceptible to extreme events, particularly flooding.

If sustainability means meeting the basic human needs for everyone on the planet, then poverty is a fundamental issue. As reported in the [United Nations' Millennium Development Goals Report](#) for 2012, less than 1.4 billion people live on less than \$1.25 per day. Once again, there is some good news in this data in that it represents a decrease compared with 1990's figure of nearly 2 billion, yet this decline has slowed significantly as a result of the global financial crisis. Moreover, in spite of this improvement, it remains a staggering number.

The long-term solution to global poverty is not simply more charity from the developed world, though there is much more that could be done. It will depend on economic development in the poverty-stricken areas of the world. For example, according to the World Bank's 2005 report, [Connecting East Asia: A New Framework for Infrastructure](#), economic development in East Asia over the prior 15 years resulted in lifting [250 million people out of poverty](#). Investments in infrastructure were critical to achieving this result.

Our collective ability to meet human needs, and the infrastructure that enables it, is also susceptible to changes – political, economic, technological, climatic, demographic, and others. Adapting to these changes requires an adaptable infrastructure, which speaks to how we design as well as the productivity of design and build activities. In the end, putting aside potential policy decisions (such as ending subsidies for flood insurance in areas susceptible to flooding), it is infrastructure that will provide the means of meeting the human needs in terms of safety, security, and adapting to change.

A focus on expanding, improving and maintaining the world's infrastructure addresses many aspects of sustainability. Given the global infrastructure deficit – basic infrastructure in the developing world and inadequate infrastructure in the developed world in terms of performance, safety, and adaptability – lives are at stake *today*.

### *Human Development Index*

Simple comparisons between conditions enjoyed in the richest countries and those endured in the poorest countries can be quite stark. When confronted with an image of extreme poverty, there is no question or ambiguity about the need – they need everything. There are many alarming statistics as well, several of which are quoted above, such as the 1.4 billion people living on less than \$1.25 day. While useful and informative, anecdotal images and gross statistics don't help us measure the magnitude of the problem in a particular country; they don't help us measure year-on-year progress in any sort of detail; nor do they help us uncover hidden problems or successes.

To help measure the state of the world and progress toward a better one in more meaningful detail, the United Nations developed the "[Human Development Index](#)" (HDI) in 1990. The purpose of the HDI is to go beyond simply economic measures, even per capita measures, to assess the condition of a population. To do this, it incorporates three dimensions of human development – health and longevity; knowledge and education; and standard of living. The United Nations publishes an annual report on human development, known as the [Human Development Report](#). This report provides the current HDI, along with a wealth of other statistics and indicators, for each country, for the world, and a number of intermediate groupings.



The choices we make as a global society in regard to infrastructure investments will directly affect the level of the quality of human life and the long-term health of the planet.

In the simplest terms, the HDI ranges from 0.0 to 1.0, where the higher the number, the greater the development. In the 2013 [report](#), the HDI ranged from 0.304 to 0.955, with the global HDI being 0.694. The countries are grouped into three categories with roughly 47 countries in each category:

- **Very High Human Development (HDI  $\geq$  0.8)**

This category includes the expected nations in North America, Europe, the Pacific Rim, and portions of Central and South America. The upper third includes most of Western Europe, the U.S., Canada, Australia, and Japan. Countries such as Poland, Lithuania, and Argentina occupy the bottom third.

- **High Human Development (0.8 > HDI  $\geq$  0.7)**

This category includes countries such as Mexico, Russia, and Kuwait in the upper half and Brazil, Iran, and Turkey in the lower half.

- **Medium Human Development (0.7 > HDI  $\geq$  0.5)**

This category includes countries such as Jordan, China, and the Philippines at the high end, and Indonesia, India, and Cambodia at the lower end.

- **Low Human Development (HDI < 0.5)**

This category includes the 46 countries that are, on average, the poorest of the poor. Among them are Pakistan, Yemen, and Haiti near the top and Mozambique, Niger, and Sierra Leone at the bottom.

The Human Development Index is certainly an imperfect number. Even one of its creators, Indian Nobel prize winner Amartya Sen, referred to it as a “[vulgar measure](#).” But it can certainly help us understand the relative standing of different countries and different regions of the world as well as *progress* toward creating societies and a world where human beings have greater opportunities to realize their full potential. **Clearly, improving standards of living, education, and health will depend heavily on investments in infrastructure. Our goal should be nothing less than enabling all people to live in conditions that reflect high human development.**

### *Environmental Issues*

If the imperative to improve and expand the world’s infrastructure wasn’t reason enough to justify Bentley’s focus on infrastructure, there are additional urgent needs associated with investments in infrastructure. The first is the global challenge to the Earth’s environment, including the long-term availability of nonrenewable resources, concentrations of pollution and waste from human activity, and global climate change. For example, the recent report from the [Intergovernmental Panel on Climate Change \(IPCC\)](#) couldn’t have been clearer regarding the impact of human activity on global climate change and its potential impact on the planet. People may disagree on the causes of climate change and the exact nature and severity of the impact, but there is near-universal acknowledgement that the planet is warming, the climate is changing, and resources are being depleted.

Progress toward environmental sustainability ... can be accelerated by addressing both the numerator and denominator of the sustainability factor.

The impact of human activity upon the environment is not limited to climate change alone. For example:

- Poor land management and the overuse of fertilizer are causing land degradation, soil erosion, and desertification on a massive scale in agricultural areas from the Amazon to the Yangtze.<sup>i</sup>
- One third of the world's population does not have access to adequate sanitation.<sup>ii</sup>
- Armed conflict affects more than 20 of the world's 34 poorest countries, mainly in Africa.<sup>iii</sup>
- Almost half the world's population will be living in areas of high water stress by 2030.<sup>iv</sup>
- Irrigation accounts for 70 percent of the world's water demand. More than half the water distributed by irrigation systems is lost due to leaks and wasteful practices.<sup>v</sup>

Clearly, action is required if we intend to sustain a planet that can support a human society in perpetuity that provides the opportunity for all people to realize the quality of life enjoyed in the developed world. **The choices we make as a global society in regard to infrastructure investments will directly affect the level of the quality of human life and the long-term health of the planet.**

### *Ecological Footprint*

In terms of measuring the overall impact of human activity on the environment, the concept of an "[ecological footprint](#)" may be useful in monitoring changes in impact of human activities. Developed in the early 1990s, it is an estimate of the amount of *biologically productive* land and sea area needed to indefinitely regenerate (if possible) the resources a given human population consumes and to absorb and render harmless the corresponding waste. Among other things, the footprint includes the area occupied by the built environment, the cropland required for food production (including pasture land), the forest land required to produce all wood and paper products, and the land required to absorb human waste products. In terms of energy, most models include the area required to absorb the CO<sub>2</sub> from energy production. Some (more conservative) methods also include the land mass required to produce the biofuel equivalent of the fossil fuel used in energy production.

There are certainly many reasonable disagreements over what should or should not be included in the models, how accurate the models are in an absolute sense, and so on. However, in a relative sense, the ecological footprint can be a good indicator of the human impact on the planet's ecosystem, that is, a measure over time of whether the situation is getting better or worse. It also is a good relative measure of the

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<sup>i</sup> Center for Strategic and International Studies. "Educating Globally Competent Citizens." Center for Strategic and International Studies, April 2010. [http://csis.org/files/publication/100416\\_Falk\\_EducatingGlobally\\_Web.pdf#page=29](http://csis.org/files/publication/100416_Falk_EducatingGlobally_Web.pdf#page=29).

<sup>ii</sup> UNICEF. "Progress on Drinking Water and Sanitation - 2012 Update." UNICEF, <http://www.unicef.org/media/files/JMPreport2012.pdf#page=20>.

<sup>iii</sup> Working Group on Armed Violence and Development. "Conflict and Fragility: Armed Violence Reduction - Enabling Development." Armed Violence and Development, 2009. <http://www.violenceanddevelopment.org/docs/oecd.pdf>.

<sup>iv</sup> United Nations. "Water Scarcity." International Decade for Action Water for Life 2005-2015, Accessed April 2012. <http://www.un.org/waterforlifedecade/scarcity.shtml>.

<sup>v</sup> Rischard, J.F. High Noon: Twenty Global Problems, Twenty Years to Solve Them, 1st ed. Basic Books, 2002.

impact of different behaviors or different geographical areas. For example, based on the ecological footprint, for everyone in the world to live the same lifestyle (have the same ecological footprint) as the average Philadelphian, seven planet Earths would be required. For the world's population to live like the average North American, more than three planets would be required.

However, focusing solely on the ecological footprint as an indicator of progress (or lack of progress) toward a more sustainable world would be limiting. The ecological footprint is largely about *changing* human activity, but it can easily be interpreted simply as *reducing* human activity. There are billions – yes, billions – of people on this Earth whose ecological footprint is quite small, but who struggle merely to survive day to day. Where is the room for these people to attain a quality of life all deserve? We could succeed in creating a more “healthy” planet from an environmental point of view and yet completely fail to meet the other test of sustainability – meeting human needs *worldwide*.

The relevance of the ecological footprint is its relationship to the *bio-capacity* of the Earth – its ability to absorb human waste and CO<sub>2</sub>, the productivity of its farmland, its ability to produce energy from its natural resources, and so on. Therefore, in addition to reducing the ecological footprint per se, measures to sustain the environment could focus on *increasing* the bio-capacity of the Earth. Maintaining or increasing the Earth's bio-capacity is not simply an altruistic endeavor. The *economic* capacity of the Earth depends directly on its bio-capacity. Infrastructure is a “force multiplier” that further increases the Earth's economic capacity enabled by its bio-capacity.

In that vein, it would be very useful to define a “sustainability index” relating the ecological footprint to the bio-capacity of the Earth, where:

$$\text{Sustainability Index} = \frac{\text{global bio-capacity}}{\text{ecological footprint}}$$

In this case, we have the opportunity to focus not only on *decreasing the denominator but increasing the numerator* as well. Defined in this way, increasing the sustainability factor is a good thing in terms of sustainability. In theory, the factor should be greater than 1.0, meaning the Earth can regenerate all of the biocapacity consumed by human activity in a given year. The one caveat would be that, just as in the case of the ecological footprint, the meaningful relevance of the sustainability factor is not necessarily its absolute value at a particular point in time, but rather its relative change over time. For example, in 1961 this factor was approximately 2.0, which could be taken to mean everything was just fine in terms of sustainability. However, given that this factor is currently about 0.67, the Earth's sustainability was clearly deteriorating rapidly, even in 1960, and is [getting worse](#), projected to be 0.5 by 2030. Progress toward environmental sustainability – improving the sustainability factor – can be accelerated by addressing both the numerator and denominator of the “sustainability factor.”

Finally, successfully meeting these challenges will require investments in infrastructure – public and private – around the world.

The performance of the “sustainability factor” over time on a global basis is shown in the following chart. The ecological footprint and biocapacity are measured in global hectares – which is a unit of measure for the average productivity of all biologically productive land in a given year. In terms of the ecological footprint, it’s a measure of the biologically productive land required to support human activity.

### *Professional Issues*

Finally, successfully meeting these challenges will require investments in infrastructure – public and private – around the world. However, money alone is not sufficient to meet these challenges. Meeting these challenges also requires a robust global community of infrastructure professionals – engineers, designers, architects, managers, scientists, and business leaders. Unfortunately, today there is a well-documented global shortage of people possessing the requisite skills to design, build, and operate the global infrastructure required to meet the twin challenges of improved quality of life for everyone and maintaining a healthy planet.

The availability of infrastructure professionals is a critical issue. Reports from governments and private industry on this topic abound. Insufficient numbers are entering the engineering fields. A Google search on technical skill shortage will return over a million hits, listing page after page of white papers, news reports, seminars, conferences, government policies, and so on, all focused on assessing, mitigating, and overcoming the issue of an acute and growing shortage of technical skills.

In its [2011 Talent Shortage Survey](#), Manpower Inc. – a global Fortune 500 firm focused on corporate human resource issues – interviewed nearly 40,000 firms in 39 countries and territories to assess the impact of labor shortages in their respective regions. Globally, 34 percent of the employers reported difficulty in filling available positions due to a shortage of skilled prospects. While this number is down from 41 percent in 2007, it is up from 30 percent in 2009, with dramatic increases in India (16 percent to 67 percent), the United States (14 percent to 52 percent), and Germany (29 percent to 40 percent). [Lloyd’s 2011 Risk Index](#), based on interviews with over 500 global C-level and board-level executives, reports that the risk associated with talent and skills shortages ranked number 2 globally, up from number 22 in 2009. In effect, we quickly moved from a credit crunch in [2009](#) to a talent crunch in 2011. According to the 2008 report by McGraw-Hill Construction, “[Key Trends in the European and U.S. Construction Marketplace](#),” the construction work force labor shortage “has escalated into near-crisis mode for firms around the world.” Even India faces a critical shortage of people in the [construction industry](#).

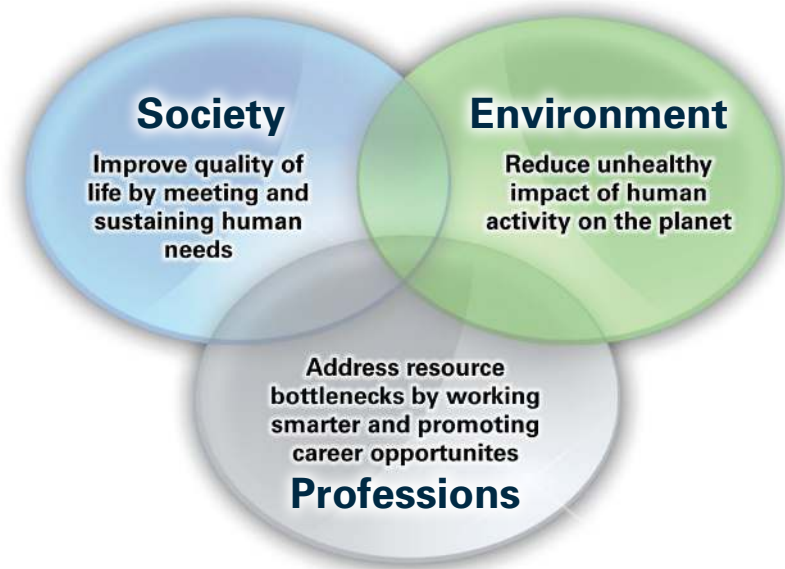
There are many factors affecting the available pool of specialized technical talent required to confront the issues we face related to the global infrastructure – aging populations, declining birthrates, societal changes, inadequate education programs, inadequate recruiting of young people to the technical professions, and so on. Again according to Manpower, Inc., “Talent shortages exist in many areas of the global labor force today, a situation that will grow more acute and more widespread across more jobs over the next 10 years – and could threaten the engines of world economic growth and prosperity.”

Addressing this growing shortage of infrastructure professionals will require recruiting more young people worldwide to infrastructure professions. It will also require tools and technology to enable existing infrastructure professionals to be more productive as well as to collaborate on infrastructure projects regardless of where those projects exist. **Responding to the sustainability imperatives for the world's infrastructure requires a sufficient pool of well-educated, motivated, and globally connected infrastructure professionals.**

## Sustaining Infrastructure

Based on the context described here, Bentley takes the view that creating a sustainable world through infrastructure requires addressing three interrelated and complex issues:

- Sustaining society
- Sustaining the environment
- Sustaining the infrastructure professions

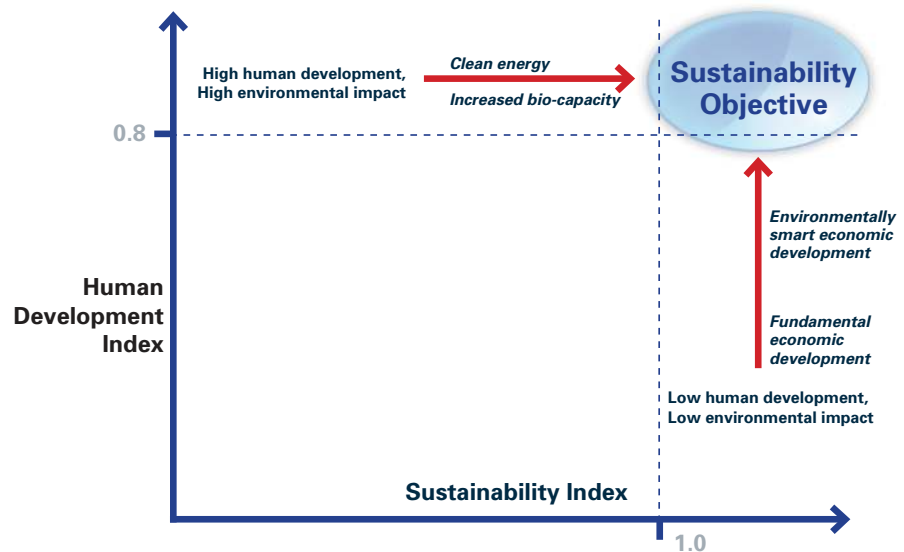


We have chosen to use the phrase “sustaining infrastructure” as an organizing concept for these activities. It is quite intentional that we chose a phrase that can be read in a number of ways in terms of our global sustainability objectives. Specifically, it refers to:

- **Creating *infrastructure* that sustains human society**  
As we’ve outlined here, infrastructure is absolutely vital to realize the global sustainability objectives for society at large, specifically as it relates to meeting the basic human needs of all people on our planet. The basic needs of all people will not be met without investments in infrastructure.

- **Creating *infrastructure* that sustains the global environment.**  
Infrastructure assets mediate the impact of human activities on the environment. Infrastructure assets themselves impact the environment. The impact in both cases can be either sustaining or destructive. Infrastructure can remediate the destructive impact of past activities and even increase the regenerative capacity of the planet. Therefore, the nature of our investments in infrastructure will have a direct impact on sustaining our planet.
- ***Sustaining the world's infrastructure* so that it can continue to provide critical services to society and the environment.**  
Infrastructure assets are long-lived, but they are subject to entropy and degradation as well. In order to continue to provide the services to sustain society and the environment, these assets must themselves be sustained.
- ***Sustaining the global infrastructure* professions to provide the brainpower to design, build, and operate sustaining infrastructure.**  
Creating and sustaining the infrastructure that our objectives for society and the environment demand requires people with a wide range of technical, managerial, and financial skills. It is incumbent on every organization involved in the infrastructure community to reach out to young people everywhere to attract them to these rewarding professions. The message is clear – we are calling on them to literally save the world.

The challenge we face is to provide all people a basic standard of living that enables them to look beyond surviving for another day while at the same time becoming good stewards of our planet by ensuring that we interact with the environment in a sustainable way. If we wish to translate this challenge into rough quantitative terms, our sustainability goals should include a Human Development Index of 0.8 for all people and a Sustainability Index above 1.0. This is undoubtedly a tall order, but it is a challenge that must be met head on and will require all the focus and innovation that we can collectively muster.



The availability of infrastructure professionals is a critical issue.

## Meeting the Sustainability Challenge

There are many approaches to meeting the challenges of sustainability through infrastructure. Within the infrastructure community, Bentley users work this problem one project at a time. In this section we outline strategies for creating a sustainable world by sustaining society, sustaining the environment, and sustaining the infrastructure professions. In many cases, innovative project examples from Bentley's *Be Inspired Awards* program are highlighted.

### Sustaining society

In terms of the definition of sustainability used here, sustaining society is primarily about meeting human needs worldwide. It involves meeting basic human needs, improving quality of life, and improving safety and security.

#### *Meeting basic human needs*

Approaches to sustaining society by meeting basic human needs relate to delivering infrastructure globally to provide a basic quality of life for all people that includes:

- **Basic infrastructure** – This refers to the delivery of basic infrastructure to people in the greatest need. For example, this would include creating the infrastructure required to provide clean drinking water and meet basic sanitation requirements in the developing world. This is not limited to rural areas. Given the significant migration to urban areas, particularly in the developing world, this also refers to providing the basic infrastructure services – housing, water, sewer – to support growing low-income populations in urban areas. The following projects completed or currently being worked on by Bentley software users have delivered basic infrastructure to those in greatest need:
  - » 2011 *Be Inspired Award* Nominee: [Agra Water Supply Project](#)
  - » 2011 *Be Inspired Award* Nominee: [Sewerage Master Plan for Delhi](#)
  - » 2011 *Be Inspired Award* Nominee: [Namibia Rural Supply Development Plan](#)
  - » 2010 *Be Inspired Award* Nominee: [Ginigathena Water Supply Project](#)
  - » 2010 *Be Inspired Award* Nominee: [Providing Water Amid Climate Change](#)
  - » 2010 *Be Inspired Award* Nominee: [Township Sewerage Model](#)
  - » 2010 *Be Inspired Award* Nominee: [Water Supply Scheme](#)
  - » Red Cross – [Tsunami Recovery Effort](#) – Bentley supported
  - » [Engineers Without Borders Software Program](#) – Bentley supported

- **Access to non-infrastructure services** – This refers to providing the means of access (roads, bridges, and communication systems, for example) to facilities (buildings, hospitals, and so on) for non-infrastructure services such as basic health and medical services, education, food distribution, and so on. The following are good examples of projects undertaken by Bentley users to create infrastructure for access to services:
  - » 2011 *Be Inspired* Award Nominee: [Bridge Over Tonto Creek](#)
  - » 2011 *Be Inspired* Award Finalist: [Mechi-Mahakali and Pokhara-Kathmandu Electrical Railway](#)
  - » 2011 *Be Inspired* Award Nominee: [Sirte-Benghazi Railway Line](#)
- **Developing the soft *infrastructure*** – This refers to efforts supporting the development of the local “soft infrastructure.” By this, we mean the awareness, education, and training for the local population in the availability, use, operation, and maintenance of the infrastructure and its related services:

### *Improving quality of life*

Beyond meeting basic needs, infrastructure provides the means for societies to thrive and grow, as enabled by approaches such as the following:

- **Improve services provided by *infrastructure* assets** – This refers to initiatives to increase the quality, scope, and choice of services provided by infrastructure that go beyond fulfilling the infrastructure requirements to meet the most basic human needs. For example, this might entail expanding the options for long-distance transportation; relieving traffic congestion; increasing the bandwidth provided by the broadband network; making more recreational area available; and so on. The following projects improved services provided by infrastructure assets:
  - » 2012 *Be Inspired* Award Nominee: [Greater Trincomalee Integrated Water Supply](#)
  - » 2012 *Be Inspired* Award Nominee: [Hydraulic Modeling](#)
  - » 2012 *Be Inspired* Award Finalist: [JICA-assisted Agra Water Supply Project](#)
  - » 2012 *Be Inspired* Award Finalist: [Nadaprabhu Kempegowda Green City Project](#)
  - » 2012 *Be Inspired* Award Nominee: [Samakhiali-Gandhidham Road Project](#)
  - » 2012 *Be Inspired* Award Nominee: [Sustainable Road Maintenance Using Mobile Mapping System](#)
  - » 2011 *Be Inspired* Award Nominee: [Metro Bridge Over Andheri Rail Line](#)
  - » 2011 *Be Inspired* Award Winner: [3x660 MW Supercritical Thermal Power Plant](#)
  - » 2011 *Be Inspired* Award Finalist: [Large-Scale District Heating Preliminary Development Project](#)
  - » 2011 *Be Inspired* Award Nominee: [Narkhed Sujal Reform Project](#)

Typically, infrastructure assets are intended to have long useful lives, often measured in decades.



- » 2011 *Be Inspired* Award Nominee: [Saoner Sujal Reform Project](#)
  - » 2010 *Be Inspired* Award Winner: [Ak-Chin Indian Community Water Reclamation Facility](#)
  - » 2010 *Be Inspired* Award Nominee: [Jnnurm Overhead Water Tank](#)
  - » 2010 *Be Inspired* Award Nominee: [New Cairo Water Supply Hydraulic Modeling Analysis](#)
  - » 2010 *Be Inspired* Award Nominee: [Potable Water Treatment Plant](#)
  - » 2010 *Be Inspired* Award Nominee: [Sustainable Water Supply in Arid Region](#)
  - » 2010 *Be Inspired* Award Winner: [Transformation of a Growing City to Vibrant Habitat](#)
  - » 2010 *Be Inspired* Award Winner: [Victoria Station Upgrade Project](#)
  - » 2010 *Be Inspired* Award Nominee: [Water Supply Sector Development Project](#)
- **Improving the availability of infrastructure services** – This would include increasing the scope of the services provided by facilities such as schools and hospitals; providing electricity and communications that are more stable and less prone to interruption; adding handicap access to existing facilities; and so on. Examples of projects that improved the availability of infrastructure services include:
    - » 2012 *Be Inspired* Award Winner: [Airport Link, Northern Busway \(Windsor to Kedron\) and Airport Roundabout Upgrade](#)
    - » 2012 *Be Inspired* Award Finalist: [Rehabilitation Center](#)
    - » 2011 *Be Inspired* Award Nominee: [Bogibil Bridge](#)
    - » 2011 *Be Inspired* Award Winner: [Panama Canal Expansion](#)
    - » 2011 *Be Inspired* Award Nominee: [AECOM Road Corridor](#)
    - » 2011 *Be Inspired* Award Nominee: [Cairo Water Network Enhancements](#)
    - » 2011 *Be Inspired* Award Nominee: [Water Supply Network for Fifa Network](#)
    - » 2010 *Be Inspired* Award Nominee: [EGIS-Ganga Expressway DPR](#)
    - » 2010 *Be Inspired* Award Winner: [Jiangxia 500 kV Transformer Substation](#)
    - » 2010 *Be Inspired* Award Nominee: [Udhampur Srinagar Baramulla Rail Link Project](#)
  - **Increase the adaptability of infrastructure** – Typically, infrastructure assets are intended to have long useful lives, often measured in decades. When measured against the increasingly rapid pace of change – political, environmental, technological, social, and so on – many infrastructure assets will undoubtedly need to be adapted or repurposed to provide expanded services, better services, or different services at some point, perhaps at multiple points, in their useful lives. To the degree infrastructure assets can be more easily adapted to new purposes, be modified more productively, and be more effectively reused, the more valuable and sustainable the asset becomes. This concept encompasses everything from designs that make the asset more adaptable to methods for recycling material or existing structures to tools that enable changes to an asset to be made faster and more economically.

### *Improving safety and security*

Even a thriving society will be subject to unexpected events or pressures – natural and man-made – that can threaten its stability and viability. Infrastructure is an important tool enabling society to protect itself against such unexpected events and mitigating their effects.

- **Improve the safety of *infrastructure* assets** – This refers to improving the safety of the services provided by infrastructure assets, for example, monitoring or improving the structural integrity of bridges and buildings. It also refers to improving the safety of the users of the asset by improving the security of the asset, making it less vulnerable to external threats. Finally, this would also include improving the safety of the asset during other phases of the lifecycle, such as during construction, when the safety of the construction personnel could be improved through better planning with a focus on safety.

Bentley solutions users were important participants in the following projects designed to improve the safety of infrastructure assets:

- » 2012 *Be Inspired* Award Winner: [Fuller Road and Washington Avenue](#)
  - » 2012 *Be Inspired* Award Nominee: [New Bridge Inspection Software System](#)
  - » 2012 *Be Inspired* Award Nominee: [Woonmoon Dam Auxiliary Spillway](#)
  - » 2011 *Be Inspired* Award Winner Special Recognition: [SFOBB East Span Seismic Safety Project](#)
  - » 2011 *Be Inspired* Award Finalist: [A1 Dishforth to Leeming Improvement Scheme](#)
  - » 2011 *Be Inspired* Award Nominee: [MicroStation Introduces Measure in Motion](#)
  - » 2011 *Be Inspired* Award Nominee: [MP/MH Border-Dhule Section of NH-03](#)
  - » 2011 *Be Inspired* Award Nominee: [NH40 Re-Engineering Designs](#)
  - » 2011 *Be Inspired* Award Winner: [Tata Soda Ash Plant](#)
  - » 2010 *Be Inspired* Award Winner: [Penang Bridge Stay Replacement](#)
  - » 2010 *Be Inspired* Award Nominee: [SH-21, Wildlife Collision Avoidance](#)
- **Mitigate impact of catastrophic events** – Nearly all infrastructure assets are subject to catastrophic external events, both natural (earthquake, tsunami, fire, severe weather, flooding) and man-made (vandalism, acts of terror, armed conflict, industrial accidents). There are many strategies for mitigating the impact of catastrophic events. Among them are hardening the infrastructure assets to better withstand potential extreme events, better planning for evacuation and recovery, better forecasting of extreme events, and better tools for first responders.

Nearly all infrastructure assets are subject to catastrophic external events, both natural and man-made.

Examples of projects whose aim was to mitigate the impact of catastrophic events include:

- » 2011 *Be Inspired* Award Finalist: [I-10 Twin Span Bridges](#)
- » 2011 *Be Inspired* Award Nominee: [W Project](#)
- » 2011 *Be Inspired* Award Finalist: [Disaster Assessment and Recovery Using Bentley Communications](#)
- » 2011 *Be Inspired* Award Nominee: [LiDAR Beam of Hope](#)
- » 2011 *Be Inspired* Award Finalist: [Figuring the Disaster Status from MMS](#)
- » 2011 *Be Inspired* Award Nominee: [LiDAR Survey for Flood Assessment](#)
- » 2011 *Be Inspired* Award Winner: [Galveston Main Wastewater Treatment Plant](#)
- » 2011 *Be Inspired* Award Winner: [Gampaha Water Purification Plant Project](#)
- » 2011 *Be Inspired* Award Finalist: [Aquasafe-Smart Management System](#)
- » 2011 *Be Inspired* Award Nominee: [Operational Diagnosis and Contingency Plan](#)
- » 2011 *Be Inspired* Award Nominee: [Analyzing Complex Stormwater Systems With Holding Ponds Below High-Tide Levels](#)

- **Adapt to climate change** – Regardless of the long-term success or failure of initiatives to reduce climate change, the climate *will change*. It will change due to human activity. It will change on its own accord through its natural cycles. Therefore, preparing to adapt to the multiple effects of climate change is a fundamentally important component of sustainability.
- The growing population and increasing density of urban areas, particularly near the coasts, renders this an important component of sustainability, even in the face of modest climate change. There are multitudes of activities that can enable us to adapt to climate change. These include restoring forest land to minimize erosion and mudslides, restoring coastal reefs and wetlands, more efficient land management, better storm water management, updating building codes, addressing issues that will be exacerbated by climate change (such as disease eradication), updating zoning regulations to minimize exposure to climate change effects, new farming methods, better predictive modeling (for flooding, for example) and risk assessment of the climate change effects, as well as adaptive “engineered ecosystems,” to name just a few.

## Sustaining the Environment

The second sustainability challenge is to become good stewards of our planet, including its environment and its resources. One element of sustaining the environment is increasing the sustainability factor above 1.0 and then keeping it there, maintaining sufficient bio-capacity to continue renewal while accommodating current and future activities by humans. Approaches include increasing bio-capacity, reducing ecological footprint, and more efficient use of nonrenewable resources.

### *Increase bio-capacity*

The following approaches to sustaining the environment are examples of *increasing* the numerator of the sustainability factor. This includes not only increasing the bio-capacity of the Earth per se, but taking advantage of the existing, untapped bio-capacity of the Earth. Finally, this would include initiatives to increase the bio-capacity of infrastructure itself, such as buildings that are net producers of power or factories that emit clean water as a by-product.

- **Take advantage of natural energy potentials** – The Earth provides many natural energy potentials, such as solar, wind, geothermal, ocean temperature gradients, hydroelectric, nuclear, and so on. The technology for taking advantage of these potentials for commercial energy production has long been a reality. For many, exploiting them more fully requires technical innovation, overcoming economic barriers, or achieving economies of scale.

The following projects tapped natural energy potentials for sustainable generation of electrical power:

- » 2012 *Be Inspired* Award Nominee: [2 Megawatt-class Offshore Wind Turbine Project](#)
- » 2012 *Be Inspired* Award Nominee: [Fendou Reservoir](#)
- » 2012 *Be Inspired* Award Finalist: [Gelantan Hydropower Station \(GLTHPP\)](#)
- » 2012 *Be Inspired* Award Nominee: [Jirau Hydropower Plant](#)
- » 2012 *Be Inspired* Award Finalist: [Solar Exposure of Copenhagen City](#)
- » 2012 *Be Inspired* Award Winner: [Spring Valley Wind Project](#)
- » 2012 *Be Inspired* Award Nominee: [Teesta-III Hydro Electric Project](#)
- » 2012 *Be Inspired* Award Nominee: [Upending Hinge Installation of Mono Piles](#)
- » 2012 *Be Inspired* Award Winner: [Utilization of the Bentley LEARN Training Subscription](#)
- » 2012 *Be Inspired* Award Winner: [Wind Turbine Test Site](#)
- » 2011 *Be Inspired* Award Winner: [Eco Renewal Project](#)
- » 2011 *Be Inspired* Award Nominee: [Tanjong Pinang Villa](#)
- » 2011 *Be Inspired* Award Nominee: [Solar-Oriented Design](#)
- » 2011 *Be Inspired* Award Nominee: [Wujin Council Building](#)
- » 2011 *Be Inspired* Award Nominee: [iUBI: Urban Bioclimatic Informer](#)
- » 2011 *Be Inspired* Award Finalist: [Tuoba Hydro-Power Station](#)
- » 2011 *Be Inspired* Award Nominee: [Mendeleevskaya Geothermal Power Station](#)
- » 2011 *Be Inspired* Award Nominee: [Sawalkot Access Road to Power Plant](#)
- » 2010 *Be Inspired* Award Nominee: [Abelvattnet Hydro Power Plant](#)
- » 2010 *Be Inspired* Award Nominee: [Give Your Photos a Position With Bentley sisNET](#)
- » 2010 *Be Inspired* Award Finalist: [Hydro Power Plant São Domingos](#)
- » 2010 *Be Inspired* Award Nominee: [Icon City Nuremberg](#)
- » 2010 *Be Inspired* Award Finalist: [Namibian Hydrological Centre of Excellence](#)

The second sustainability challenge is to become good stewards of our planet, including its environment and its resources.

- » 2010 *Be Inspired* Award Nominee: [Photovoltech Solar Factory](#)
- » 2010 *Be Inspired* Award Finalist: [Pumped Storage Power Station](#)
- » 2010 *Be Inspired* Award Nominee: [Residential Building and Public Facilities](#)
- » 2010 *Be Inspired* Award Nominee: [Strata SE1](#)

- **Expand ability to absorb waste** – This refers primarily to increasing the natural ability of the Earth to absorb green house gases by increasing green space through recovery of waste sites, plankton growth in the oceans, reforestation, recovery of arid land, increased urban green space, green building roofs, and so on. It also includes implementing [carbon sequestration](#) projects to absorb carbon dioxide from the atmosphere through approaches such as underground storage, ocean storage, chemical storage within minerals, storing the carbon by-products of [power generation](#), and so on.

Reducing greenhouse gasses was the goal of the following projects undertaken by Bentley users:

- » 2011 *Be Inspired* Award Nominee: [New Exhibition Center](#)

- **Remediate impact of human activity** – The bio-capacity of the Earth can be increased by recovering bio-capacity lost to prior human activity. This includes solutions such as hazardous waste recovery and disposal; treatment of polluted water; cleaning polluted air (with urban forests, for example); recovering green spaces lost to activities such as mining and landfills; mining landfills for resource recovery; and so on.

The following are a few of the many infrastructure projects designed to remediate the impact of human activity:

- » 2012 *Be Inspired* Award Winner Special Recognition: [Metro Wastewater Reclamation District, Northern Treatment Plant](#)
- » 2011 *Be Inspired* Award Nominee: [Noise Barrier at National Park Dwingelderveid](#)
- » 2011 *Be Inspired* Award Nominee: [Boliden Electronic Scrap Recycling Facility](#)
- » 2011 *Be Inspired* Award Nominee: [Promenade Champlain-Phase III-Front End](#)
- » 2011 *Be Inspired* Award Finalist: [Gippsland Water Facility](#)
- » 2011 *Be Inspired* Award Nominee: [DSD Shatin Sewage Treatment Works 3D Model](#)
- » 2010 *Be Inspired* Award Finalist: [Denver Metro Wastewater Reclamation District](#)
- » 2010 *Be Inspired* Award Nominee: [SITA Re-energy Bavaro Project](#)

## Reduce Ecological Footprint

These approaches to sustaining the environment are examples of decreasing the denominator of the sustainability factor – reducing the ecological footprint resulting from continuing human activity.

- **Reduce or eliminate greenhouse gas emissions** – This is currently perhaps the most visible and active area in terms of reducing the ecological footprint as it relates to mitigating global warming and resultant climate change. The multitude of approaches include designing buildings with “green” materials; designing buildings with a greater degree of natural cooling, heating, and lighting; more accurate assessment and optimization of building performance during the design phase; real-time monitoring and optimization of building energy usage; and so on. This also encompasses “clean” (without CO<sub>2</sub> emissions) electricity generation (with some overlap with increasing bio-capacity approaches) and alternatives to petroleum products for transportation.

Reducing or eliminating greenhouse gas emissions was the goal of the following projects:

- » 2012 *Be Inspired* Award Nominee: [Gaya Sewerage Scheme](#)
- » 2011 *Be Inspired* Award Nominee: [Zero Carbon Multifamily House](#)
- » 2011 *Be Inspired* Award Nominee: [Low-Pressure Gas Compressor Station](#)
- » 2010 *Be Inspired* Award Nominee: [Coke Oven Gas Desulfurization](#)
- » 2010 *Be Inspired* Award Winner: [Department of Energy-Biomass Cogeneration Facility](#)
- » 2010 *Be Inspired* Award Nominee: [Motor Spirit Quality Upgrade](#)
- » 2010 *Be Inspired* Award Nominee: [PCI Building for Blast Furnace](#)

- **Reduce or eliminate detrimental environmental impact** – This refers to the well-known and long-standing initiatives to reduce the overall environmental impact of new infrastructure projects. It also includes initiatives to reduce pollutant emissions from commercial facilities. This includes designing new facilities that produce less pollutant waste; retrofitting existing facilities to capture or process pollutants; repurposing waste products for use in other processes; and so on.

The following projects were designed to minimize detrimental environmental impact of infrastructure:

- » 2012 *Be Inspired* Award Nominee: [Ammonia Plant Feedstock Changeover Project](#)
- » 2012 *Be Inspired* Award Nominee: [Electricity of Portugal](#)
- » 2012 *Be Inspired* Award Nominee: [Fulton Street Transit Center](#)
- » 2012 *Be Inspired* Award Winner: [LAX International Terminal Expansion](#)

The bio-capacity of the Earth can be increased by recovering bio-capacity lost to prior human activity.

- » 2012 *Be Inspired* Award Nominee: [Sewerage Master Plan of Delhi for the Year 2031](#)
  - » 2012 *Be Inspired* Award Nominee: [Strategic Center for Earthquake Emergency](#)
  - » 2011 *Be Inspired* Award Finalist: [SH 161 Phase 4](#)
  - » 2011 *Be Inspired* Award Nominee: [The Island at Pierce College](#)
  - » 2011 *Be Inspired* Award Finalist: [Planning Innovation of a Medical Center](#)
  - » 2011 *Be Inspired* Award Nominee: [Coal Power Plant 2x800MW Westphalia](#)
  - » 2011 *Be Inspired* Award Nominee: [Network Thermal Energy Storage Used as a Way to Increase Cogeneration Power Fed Into the Grid](#)
  - » 2010 *Be Inspired* Award Nominee: [Aveiro Port Feeder Line](#)
  - » 2010 *Be Inspired* Award Nominee: [Effluent Treatment Plant CEMP Phase II](#)
  - » 2010 *Be Inspired* Award Nominee: [Las Cruces Army Reserve Center](#)
  - » 2010 *Be Inspired* Award Nominee: [Lube Oil Blending Plant](#)
  - » 2010 *Be Inspired* Award Winner: [Meath EFW](#)
  - » 2010 *Be Inspired* Award Finalist: [Real-Time Energy Optimization Implementation](#)
  - » 2010 *Be Inspired* Award Nominee: [Shed for 250KW Biomass Project](#)
  - » 2010 *Be Inspired* Award Nominee: [Sustainable Construction Process Hanzelijn](#)
- **Extend life and reuse infrastructure assets** – Another mechanism for reducing the ecological footprint is to eliminate the footprint from material production and transportation, construction, debris and waste removal, and so on associated with new construction by extending the useful life of infrastructure assets as well as adapting them for new uses. Extending the useful life of infrastructure assets was the goal of the following projects:
    - » 2012 *Be Inspired* Award Nominee: [Dearborn-Ypsilanti Second Track](#)
    - » 2011 *Be Inspired* Award Nominee: [Bora Agro Foods](#)
    - » 2011 *Be Inspired* Award Nominee: [HERO Ultra Pure Water Systems](#)
    - » 2011 *Be Inspired* Award Finalist: [Sludge Treatment Facility](#)

#### ***More efficient use of nonrenewable resources***

Given the current global dependence on many nonrenewable resources, consumption of nonrenewable resources continues for the foreseeable future. More efficiently extracting, processing, and consuming these resources will extend the window for replacing them with renewable sources. Infrastructure projects that result in more efficient use of resources have the potential of improving both the numerator and denominator of the sustainability factor.

Meeting the challenges to sustain both society and the environment requires a global pool of infrastructure professionals armed with effective knowledge and tools.

- **More efficient consumption** – The obvious initiative in regard to nonrenewable resources is to consume them more efficiently. This involves, for example, greater energy efficiency; alternate modes of transportation (such as mass transit); elimination or replacement of unnecessary activities (by telecommuting, video conferencing, and so on); and use of new materials that require less energy to produce and transport. These are all examples of more efficient consumption. Likewise, designs that result in products that are more readily and efficiently recycled, including “[Cradle to Cradle](#)” certified products, are further examples of more efficient consumption.

The following projects targeted more efficient consumption:

- » 2012 *Be Inspired* Award Nominee: [Cadiriri Booster Supply Analysis](#)
- » 2012 *Be Inspired* Award Nominee: [Improving Efficiency of Pump Operations in Manila](#)
- » 2012 *Be Inspired* Award Nominee: [Mega City Water Supply System](#)
- » 2011 *Be Inspired* Award Nominee: [Evolutionary Strategy To Design Optimized Architecture](#)
- » 2010 *Be Inspired* Award Nominee: [Bellevue College Health Sciences Building](#)
- » 2010 *Be Inspired* Award Nominee: [CNY Biotechnology Research Center](#)
- » 2010 *Be Inspired* Award Nominee: [Energy Modeling Using Hevacomp](#)

- **More efficient production** – In addition to consumption, there are opportunities to more efficiently produce by-products from raw materials, including processes that consume less energy and produce less waste; processes that produce a higher yield for the same raw material; more efficient means of transport; reuse of by-products; and so on. More efficient production was the goal of the following projects:

- » 2012 *Be Inspired* Award Nominee: [Deulgaon Raja Sujal Reform Project](#)
- » 2012 *Be Inspired* Award Nominee: [Softened Water to DM Water Service and Condensate Heat Recovery and Integration](#)
- » 2011 *Be Inspired* Award Nominee: [Inconceivable Transports](#)
- » 2011 *Be Inspired* Award Nominee: [Volkswagen Efficient Space Management](#)
- » 2011 *Be Inspired* Award Nominee: [Master Plan for Improvement of Water Supply System in Delhi](#)
- » 2011 *Be Inspired* Award Nominee: [Optimization Design for Sustainable Supply](#)
- » 2011 *Be Inspired* Award Nominee: [Sustaining Economic Growth Through Energy-Efficient Initiatives](#)
- » 2010 *Be Inspired* Award Nominee: [A Sustainable Approach in Water Transmission](#)



The road to a sustainable world will be paved by the vision, commitment, innovation, open-mindedness, and pragmatism of infrastructure professionals.

- » 2010 *Be Inspired* Award Finalist: [Design Optimization of Complex Roofs](#)
- » 2010 *Be Inspired* Award Nominee: [Green Automobile Plant in China](#)
- » 2010 *Be Inspired* Award Nominee: [Hydrometers Readjustment-PAHI Project](#)
- » 2010 *Be Inspired* Award Nominee: [Mundra](#)
- » 2010 *Be Inspired* Award Nominee: [Supply Optimization and Energy Reduction](#)

- **Expand global resource supplies** – Given the ultimate limits on nonrenewable resources, expanding the global resource supplies is also an approach to extending the availability of nonrenewable resources, and ensuring their continuing availability even as they are being replaced for some uses by renewable sources. These approaches could include more complete and efficient extraction methods; more effective and accurate exploration; more eco-friendly exploration and extraction; and so on.

The following projects are examples of efforts to expand the availability of global resources:

- » 2011 *Be Inspired* Award Finalist: [Gas Recovery and Injection Project](#)
- » 2011 *Be Inspired* Award Nominee: [Ousahwira Oil Field Development Project](#)

## Sustaining the Infrastructure Professions

Meeting the challenges to sustain both society and the environment requires a global pool of infrastructure professionals armed with effective knowledge and tools. Our pool of infrastructure professionals is increasingly inadequate. Initiatives intended to overcome these shortages include attract and educate, renew, and enable.

### *Attract and educate*

Critical to expanding the pool of infrastructure professionals are both attracting students to the infrastructure professions and providing them with the appropriate education in the infrastructure professions to enable them to contribute to global sustainability.

- **Attract students to sciences and engineering** – The most fundamental requirement in the long term is to attract young students to the sciences and ultimately the technical fields, such as engineering, relevant to infrastructure. Approaches to this include supporting elementary and middle school programs to promote interest in science and math such as the National Engineers Week Future City Competition. Equally important is supporting high school programs to promote interest in engineering with programs such as the Wooden Bridge Contest and robotics competitions.

Programs dedicated to attracting students to the sciences and engineering include the following:

- » [National Engineers Week Future City Competition](#) – Bentley supported
- » [Future Cities India 2020](#) – Bentley supported
- » [Future Cities China](#) – Bentley supported
- » [Be Mentors Program](#) – Bentley supported

- **Focus undergraduates on infrastructure professions** – Once students have chosen to pursue a technical career, it is also necessary to attract them to the infrastructure professions. Initiatives to do this would include supporting university programs and competitions focusing on infrastructure (the Solar Decathlon, for example), as well as supporting university-level volunteer programs working on projects in the developing world, including Engineers Without Borders, HOPE Worldwide, and others. In addition, implementing active internship and co-op programs within infrastructure-related companies will also support this objective.

The following educators have been recognized for their outstanding record of achievement and commitment to inspiring students to pursue careers in the infrastructure professions:

- » 2012 *Be Inspired* Award Winner: [Guenter Maresch, Ph.D., Educator of the Year](#)
- » 2011 *Be Inspired* Award Winner: [Maria-Paz Gutierrez, Educator of the Year](#)
- » 2010 *Be Inspired* Award Winner: [Efrat Gilboa, Educator of the Year](#)

- **Support, focus, and leverage university research** – There is significant anecdotal evidence that university-level research is not leveraged to the degree possible. There are many factors contributing to this. Unlike the aerospace, automotive, and defense industries, the infrastructure community is very diverse, highly fragmented, and often operates locally. Thus there are not large budgets available for broad, long-term initiatives to study fundamental infrastructure issues. Most research is funneled into industry through consortiums or by hiring the researchers directly. Corporate involvement is largely through modest monetary grants. What is required is the active *engagement* in and support of research by the members of the infrastructure professions. This will enable practitioners to realize the research results more directly, as well as help focus the research initiatives on issues that are immediately relevant to the infrastructure industry.

Bentley efforts to support, focus, and leverage university research are advanced by the Bentley Applied Research team:

» ***Bentley Initiative – Bentley Applied Research***

- *University of Pennsylvania, Virginia Tech, MIT, Polytechnic University, Johns Hopkins, McGill University (Canada), Technical University of Delft (Netherlands), Strathclyde University (UK), University College of London, University of Colorado, Simon Fraser University (Canada)*

***Renew***

Maximizing the effectiveness of existing infrastructure professionals requires continuous renewal of the appropriate skills.

- **Institutionalize continuous learning** – The concept and value of continuous learning is generally well understood. However, within “episodic” (largely project-based) domains such as infrastructure, investments in training are often ranked fairly low among the investment priorities of many organizations. Continuous learning applies not only to professionals within the infrastructure community, but initiatives to retrain people from other industries in infrastructure-relevant skills. This would also include adopting programs to enable colleagues to gain certification in sustainability related areas such as Leadership in Energy and Environmental Design ([LEED](#)).

The following Bentley software users were nominated for *Be Inspired Awards* for their success in institutionalizing continuous learning:

- » 2012 *Be Inspired Award Winner* Special Recognition: [Utilization of the Bentley LEARN Training Subscription](#)
- » 2011 *Be Inspired Award Winner*: [Utilization of the Bentley LEARN Training Subscription](#)

- **Implement new forms of learning** – The effective implementation of continuous learning requires new forms of learning, those that go beyond traditional classroom instruction. This is particularly true given the distributed nature of projects and enterprises within the infrastructure community. Distance learning, self-service online content, and “just-in-time” learning are some of the methods that can facilitate continuous learning.

- » 2012 *Be Inspired Award Winner* Special Recognition: [Airport Link, Northern Busway \(Windsor to Kedron\) and Airport Roundabout Upgrade](#)

The following programs are examples of implementing new forms of learning:

- » [Denver’s Road Home BEST Work Exchange Program](#) – Bentley supported
- » 2010 *Be Inspired Award Winner*: [iPas DT Sustainable Training Initiative](#)

- **Foster communities of infrastructure professionals** – The communities of infrastructure professionals are necessarily distributed all around the world. However, the near universal connectivity made possible by the Internet opens the possibility of creating online, worldwide communities of infrastructure professionals. Concepts like social networking can be extended into the infrastructure community to create focused virtual communities for sharing ideas and experiences, collaborating on projects, education, and other activities.

The purpose of Be Communities is to foster communities of infrastructure professionals.

» Bentley Initiative – [Be Communities](#)

### *Enable*

The work accomplished by the existing pool of infrastructure professionals can be increased by equipping individual professionals, work groups, distributed project teams, and the entire supply chain for infrastructure projects with more effective tools for performing their work.

- **Tools for increased productivity** – This refers to expanding the use of existing information technology tools for all phases of the infrastructure asset lifecycle, along with better tools from technology vendors, to improve productivity and quality. This also includes increasing reuse of information, particularly through the adoption and widespread use of industry standards, as well as specific, high-return initiatives such as more direct use of design information in support of construction and construction management tasks:
  - » 2011 *Be Inspired* Award Finalist: [Hongyan River Nuclear Power Plant](#)
  - » 2011 *Be Inspired* Award Finalist: [Carotino Fatty Acid Splitting Plant](#)
  - » 2011 *Be Inspired* Award Nominee: [Computer-Aided Design of Compressor Stations](#)
  - » 2011 *Be Inspired* Award Finalist: [Glenfield Transport Interchange](#)
  - » 2011 *Be Inspired* Award Nominee: [Gurgaon-Faridabad Major District Road](#)
  - » 2010 *Be Inspired* Award Nominee: [Coal-Handling Plant](#)
  - » 2010 *Be Inspired* Award Nominee: [Wire Rod Mill](#)
- **Tools to design, analyze, and assess for sustainability** – This refers to information technology tools – either by adapting existing tools or creating new built-for-purpose tools – that directly address the sustainability issues raised here.

The following Bentley products are used to design, analyze, and assess infrastructure for sustainability:

- » Bentley Products – [Structural Analysis & Design](#)
  - » Bentley Products – [Engineering Analysis](#)
  - » Bentley Products – [Water Solutions](#)
  - » Bentley Products – [Building Services & Simulation](#)
- **Tools to globally connect infrastructure professionals** –  
One immediate mechanism for increasing the availability of infrastructure professionals, particularly for a specific project, is through the widespread adoption of technology to connect and enable collaboration among globally distributed professionals.

The following projects exemplify successful connection of infrastructure professionals in distributed enterprises:

- » 2012 *Be Inspired* Award Finalist: [Dudley Square Municipal Building](#)
- » 2012 *Be Inspired* Award Finalist: [I-74 Mississippi River Crossing Corridor](#)
- » 2012 *Be Inspired* Award Nominee: [New Jersey Turnpike](#)
- » 2012 *Be Inspired* Award Winner Special Recognition: [Virginia City Hybrid Energy Center](#)
- » 2011 *Be Inspired* Award Nominee: [PWB Bull Run Supply Treatment](#)
- » 2011 *Be Inspired* Award Winner: [Midfield Development Design Consultancy Services](#)
- » 2010 *Be Inspired* Award Winner: [Crossrail](#)
- » 2010 *Be Inspired* Award Winner: [GIS4Mobile-Connect Online Mobile Device](#)
- » 2010 *Be Inspired* Award Nominee: [Michigan Runs on ProjectWise](#)
- » 2010 *Be Inspired* Award Nominee: [ProjectWise Lifecycle Server Implementation](#)
- » 2010 *Be Inspired* Award Nominee: [Proof of Concept ISO 15926](#)

## Conclusion

Sustainability is not a single issue. It's not limited to global warming, climate change, pollution, chronic hunger, unsafe bridges, public health, or contaminated water – it is all of these and more.

It's not a problem that we'll solve and then move on – it will require constant, continuing, and unrelenting attention. The issues and challenges surrounding sustainability are broad, complex, and interrelated.

To completely satisfy our sustainability objectives will mean more investment in infrastructure, not less. It will mean more economic development, not less.

As has been convincingly argued by some, until people reach a certain level of affluence, concerning themselves with global sustainability is a luxury they cannot afford. For the nearly 5 billion people living on less than \$2 per day, the primary sustainability objective is simply to sustain themselves and their families for another day. If our goal is for all people to be concerned with global sustainability, then the prerequisite is to enable all people to enjoy a quality of life that affords them that luxury. This is a significant challenge for society, a significant challenge for the world's infrastructure, and a challenge for all of us as members of the infrastructure professions.

In his book *The Brothers Karamazov*, Dostoyevsky's main character, Yvan, is talking to his brother, who happens to be a priest, about suffering in the world:

*Imagine that you are creating a fabric of human destiny with the object of making men happy in the end, giving them peace and rest at last. Imagine that you are doing this but that it is essential and inevitable to torture to death only one tiny creature...in order to found that edifice on its unavenged tears. Would you consent to be the architect on those conditions? Tell me. Tell me the truth.*

When we complain about the World Bank funding another coal plan in India because of the carbon dioxide, to which child do we say, "Sorry, you'll have to wait for that electric pump that will finally bring clean water to your village because we here in the developing world are spewing too much carbon"? When we rail against genetically altered seeds that are more productive and disease resistant because it's "unnatural," to which starving child do we say, "Sorry, your crops won't yield enough again this year, so go hungry for a while longer"? When we refuse to get aggressive about adapting to climate change because people might get lazy about trying to stop climate change, to which child do we say, "Sorry, we can't provide you that mosquito net just yet because we have to teach people a lesson"? Yes, tell me, tell me the truth.

In order to meet this challenge, technology companies such as Bentley must provide solutions that are comprehensive, interoperable, and productive.

However, when it comes to addressing the elements of sustaining infrastructure – society, environment, and the infrastructure professions – vision, commitment, and engagement are just as important as individual features of software applications.

In the end, sustainability is about nothing less than how we, as a global society, choose to live on this planet. Science alone will not dictate the steps we need to take to create a sustainable world. Science can only help us predict the consequences of the choices we make.

Likewise, the market alone will not guide us to a sustainable world. The market's invisible hand will efficiently optimize our investments within the bounds of its regulations and incentives, but we must make the fundamental choices as to those regulations and constraints. Science and the market are powerful tools, but they are only tools – not altars.

The road to a sustainable world will be paved by the vision, commitment, innovation, open-mindedness, and pragmatism of infrastructure professionals.

“It is astonishing to see how many philosophical disputes collapse into insignificance the moment you subject them to this simple test of tracing a concrete consequence. There can be no difference anywhere that doesn't make a difference elsewhere – no difference in abstract truth that doesn't express itself in a difference in concrete fact and in conduct consequent upon that fact, imposed on somebody, somehow, somewhere, and somewhen. The whole function of philosophy ought to be to find out what definite difference it will make to you and me, at definite instants in our life, if this world-formula or that world-formula be a true one.

A pragmatist . . . turns away from abstraction and insufficiency, from verbal solutions, from bad a priori reasons, from fixed principles, closed systems, and pretended absolutes and origins. He turns towards concreteness and adequacy, towards facts, towards action and towards power . . . It means the open air and possibilities of nature, as against dogma, artificiality, and the pretence of the finality in truth.”

– William James, 1885