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Investigating strategies and indicators for Sustainable campus: Comparison and synergies between University of Bologna and Delft University of Technology

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ABSTRACT

Sustainable development is one of the biggest challenges of the twenty fist-century. Various university has begun the debate about the content of this concept and the ways in which to integrate it into their policy, organization and activities. Universities have a special responsibility to take over a leading position by demonstrating best practices that sustain and educate a sustainable society. For that reason universities have the opportunity to create the culture of sustainability for today's student, and to set their expectations for how the world should be.

This thesis aim at analyzing how Delft University of Technology and University of Bologna face the challenge of becoming a sustainable campus. In this context, both universities have been studied and analyzed following the International Sustainable Campus Network (ISCN) methodology that provides a common framework to formalize commitments and goals at campus level. In particular this work has been aimed to highlight which key performance indicators are essential to reach sustainability as a consequence the following aspects has been taken into consideration: energy use, water use, solid waste and recycling, carbon emission.

Subsequently, in order to provide a better understanding of the current state of sustainability on University of Bologna and Delft University of Technology, and potential strategies to achieve the stated objective, a SWOT Analysis has been undertaken. Strengths, weaknesses, opportunities and threats have been shown to understand how the two universities can implement a synergy to improve each other. In the direction of framing a "Sustainable SWOT" has been considered the model proposed by People and Planet, so it has been necessary to evaluate important matters as for instance policy, investment, management, education and engagement. Regarding this, it has been fundamental to involve the main sustainability coordinators of the two universities, this has been achieved through a brainstorming session.

Partnerships are key to the achievement of sustainability. The creation of a bridge between two universities aims to join forces and to create a new generation of talent. As a result, people can become able to support universities in the exchange of information, ideas, and best practices for achieving sustainable campus operations and integrating sustainability in research and teaching. For this purpose

the project "SUCCESS" has been presented, the project aims to create an interactive European campus network that can be considered a strategic key player for sustainable campus innovation in Europe.

Specifically, the main key performance indicators have been analyzed and the importance they have for the two universities and their strategic impact have been highlighted. For this reason, a survey was conducted with people who play crucial roles for sustainability within the two universities and they were asked to evaluate the KPIs of the project. This assessment has been relevant because has represented the foundation to develop a strategy to create a true collaboration. Subsequently, three strategies have been suggested, based on the importance that each KPI has for the universities, with detailed regard on commitment, responsibility, authority, accountability, and sharing of resources, risks, and rewards.

Finally, through the analysis of one of the first SUCCESS project goal, concerning the establishment of a transition team in each campus, a viable example to begin a transition towards a sustainable university is proposed.

ABSTRACT

Lo sviluppo sostenibile rappresenta una delle più grandi sfide del XXI secolo. Diverse università hanno già da tempo intrapreso il dibattito verso questo tema ed hanno iniziato a studiare il modo in cui integrarlo nella politica universitaria, nell'organizzazione e nelle attività. Le università possiedono una speciale responsabilità, poiché detengono una posizione di leadership, attraverso la dimostrazione di best practice sono in grado di sostenere ed educare una società sostenibile. Le università hanno di conseguenza la possibilità di creare una cultura di sostenibilità per gli studenti di oggi, e di impostare le loro aspettative su come il mondo dovrebbe essere.

L'obiettivo di questa tesi è di analizzare come Delft University of Technology e l'Università di Bologna affrontano questa sfida al fine di diventare un campus sostenibile. In tale contesto, entrambe le università sono state studiate secondo la metodologia proposta dall'International Sustainable Campus Network, che fornisce un quadro comune per formalizzare impegni e obiettivi a livello di campus. In particolare, questo lavoro evidenzia quali key performance indicators siano essenziali per protendere verso la sostenibilità, di conseguenza sono stati studiati i seguenti aspetti: uso dell'energia, uso dell'acqua, rifiuti e riciclaggio ed infine emissioni dannose.

Di conseguenza, per permettere una migliore comprensione dello stato dell'arte e delle possibili strategie implementabili per le due università è stata svolta un'analisi SWOT. Punti di forza, punti di debolezza, opportunità e minacce sono stati esaminati con l'obiettivo di capire come le università possano sviluppare un azione sinergica per migliorarsi l'un l'altra. Per ottenere un'analisi "SWOT sostenibile" è stato considerato il modello proposto da People and Planet, che ha permesso di valutare diversi importanti aspetti tra cui politica, investimenti, gestione ed educazione. È stato quindi necessario coinvolgere i principali coordinatori della sostenibilità delle due università e ciò è stato attuato attraverso un brainstorming.

La partnership rappresenta un elemento chiave per ottenere la sostenibilità. La creazione di un ponte tra le due università rappresenta quindi un modo per unire le forze e creare una nuova generazione di talenti. Persone in grado di sostenere lo

scambio d’informazioni, idee e best practice con l’obiettivo di operare verso un campus sostenibile sia nella ricerca che nell’insegnamento.

A tal proposito, in questa tesi è presentato il progetto "SUCCESS", il quale mira alla creazione di una rete europea di campus interattivi, che rappresenta una chiave strategica per le innovazioni di campus sostenibili in Europa. In particolare sono stati analizzati i principali key performance indicators ed è stata messa in evidenza l’importanza che ricoprono per le due università e il loro impatto strategico. Per questo scopo, è stato condotto un sondaggio che ha visto coinvolte le persone che ricoprono un ruolo fondamentale per la sostenibilità, ed è stato chiesto loro di valutare i KPI del progetto in ottica d’importanza. Questa valutazione è stata cruciale perché ha rappresentato la base per realizzare una strategia di collaborazione. Successivamente, sono state proposte tre strategie, basate sull’importanza che ogni KPI ricopre per le due università, con un focus dettagliato verso impegno, responsabilità, autorità, condivisione delle risorse, rischi e benefici.

Infine, attraverso l'analisi del primo sotto-obiettivo del progetto “SUCCESS”, ovvero la creazione di un transition team in ogni campus, viene proposto un possibile esempio di come intraprendere una transizione verso un’università sostenibile.

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1 Introduction

Climate change has long-since recognized as the major preponderant environmental issue of our time. At the same time, it can be the greatest challenge facing our society. Really, the transition toward a low carbon society is a long process involving not only technology system but also the whole society. Therefore a whole-system approach is required involving multi-actors and multi-societal dimensions. In the process to invent and develop sustainable system innovation, the role of campuses is crucial in order to enhance the transition towards a low-carbon society.[1]

"Higher education institutions bear a profound, moral responsibility to increase the awareness, knowledge, skills, and values needed to create a just and sustainable future" (Cortese, 2003)

The citation above emphasizes that universities should not ignore the increasing environmental concerns. Universities need to step up and serve as an example to society at large by transforming their institutions and their campuses into organizations embracing sustainability. Since the 1990s, this statement has been adopted in many declarations, moving universities slowly in the direction of integrating sustainability in their mission.[2]

The notion of integrating sustainability can be interpreted in a number of ways. Many universities are now showcasing sustainability initiatives by highlighting project-based campus operation improvements to reduce ecological footprint. In this latter approach sustainability is embedded in education, research, and knowledge transfer (outreach); it combines its core businesses with the support system of operations and administration.

In my thesis, I illustrate the case study of two universities, the largest and oldest Dutch public technical university: Delft University of Technology; and the oldest existing universities in the world: the Italian University of Bologna.

[1] Cappellaro, F. de Werk, G., Nagel, J., Bonoli A., Spada, M. Sustainable Campus Initiatives for boosting Low Carbon Innovation. Journal of Cleaner Production (approved)
[2] See, Grindsted (2011) for an overview of 31 declarations.

I have chosen these universities because the first one is the university where I spent my engineering studies for five years, the second one is the university where I spent a research period of five months. At Delft University of Technology I could study the topic of sustainable university thanks to the involvement in the pathfinder project 'Sustainable Campus Launching Customer' (SCLC) where I could give my contribution.

Therefore the objective has been to analyze the 'sustainable university campus' concept in order to understand how the synergies among the two universities of transition from non-sustainability to sustainability may be improved. For the purpose of my research, I have applied the methodology of the International Sustainable Campus Network to describe commitments and goals on campus sustainability. The mission of the International Sustainable Campus Network (ISCN) is to provide a global forum to support leading colleges, universities, and corporate campuses in the exchange of information, ideas, and best practices for achieving sustainable campus operations and integrating sustainability in research and teaching.[3] The methodology means a Charter structures campus commitments about sustainability into a nested hierarchy encompassing individual buildings, campus-wide planning and target setting, and integration of research, teaching, outreach and facilities for sustainability. Subsequently, strengths, weaknesses, opportunities and threats have been showed in order to understand how the two universities can implement a synergy to improve each other.

In the end, the project "SUCCESS - Synergetic University Campuses boosting ClimatE innovationS" is presented as a way to reach the scope of creating a bridge between the two universities. This project comes from the pathfinder project SCLC and it is the future evolution in the framework of the European Institute of Innovation & Technology (EIT): Climate-KIC. Both Delft University of Technology and University of Bologna are partners of Climate KIC that providing them to be involved in project concerning sustainable campus.

Climate-KIC is Europe's largest public-private innovation partnership focused on climate innovation. In addition, The Climate-KIC is such an organization as it subsidizes projects that aim to mitigate or adapt to climate change.

[3] http://www.international-sustainable-campus-network.org/

This project fits within the scope of Climate KIC as it aims to completely change the role, attitude and perception of campuses. It develops bridges between campus inhabitants, European campuses towards society in a way that has never been thought of before. It changes the science and technology push form university into demand pull to really actively start solving societies' challenges by involving the regions and all campus inhabitants in the innovation process.

The research adopts a transition perspective, in particular the Transition Management Approach. The concepts of transition and transition management offer a fruitful context for cooperation and debate among scientists within the university.

Transition management and transition approach in general provide an integrative approach to analyze and formulate an unconventional pathway towards sustainability. Effectively the "SUCCESS" project is focused on sustainability transition, a promising approach towards a sustainability and also climate innovation.

In conclusion, the objective of this research is to understand why it is important to create processes that underlie and enhance the transformation of Delft University of Technology and University of Bologna into a sustainable university campus.

2 Environmental changes and their causes

The rise of a worldwide industrial civilization during the past century and the parallel development of more intensive forms of agriculture – based on the use of chemical fertilizers, insecticides and herbicides – needed to feed and clothe a rapidly expanding population has placed unprecedented pressures and stresses on the world's ecosystems. The problems and dangers are manifold. In industrialized regions, the combustion of fossil fuels, the 'life blood' of modern civilization, is resulting in an acidification of soils which is having a destructive impact on plants, forests and aquatic life in lakes and rivers. The use of fossil fuels is also responsible for the build-up of 'greenhouse gases' that are a key factor in global warming which is changing weather patterns and raising ocean levels around the world. Even a modest rise in the Earth's average temperature, of say two to three degrees, would result in the inundation of vast amounts of fertile low-lying coastal lands and the disappearance of many islands. A growing dependence on chemicals, many of which have never existed in nature, is having a damaging impact on plants and animals, leading even to the extinction of certain species and thus to a reduction in the world's biodiversity. Chemicals are affecting the stratosphere, depleting ozone and exposing the Earth's surface to higher levels of ultra-violet radiation known to cause skin and other cancers. In the developing countries, land degradation presents perhaps the most immediate and urgent problem. As agricultural land per capita diminishes as a result of population growth and urbanization, it becomes essential to preserve the productivity of every available acre.

Yet, perhaps the greatest environmental danger lies in problems that are little discussed, even among scientists, such as the impact of human activities on natural 'nutrient cycles' required to produce and balance elements essential to life: including carbon, oxygen and nitrogen. While the long-term affects of anthropogenic activities on the environment are either unknown or poorly understood, it is abundantly clear that delicate balances are being disturbed and disrupted. Some of these changes – e.g. the extinction of species – are already irreversible. Other processes may soon pass the point of no return, if action is not taken promptly. Yet, measures to protect the environment are resisted by those

who insist that the needs of development – rising living standards for growing numbers – must take precedence over ecological concerns. The challenge of sustainability involves reconciling and adjudicating conflicting claims and moving towards a development which is environmentally sound.[4]

2.1 Evidence of climate change

The Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC)[5] strongly shows that human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems.

Human activities, particularly emission of carbon dioxide, are causing a sustained and unequivocal rise in global temperatures. Concurrently, the rise in global temperatures is causing changes in all geographical regions: the atmosphere and oceans are warming, the extent and volume of snow and ice are diminishing, sea levels are rising and weather patterns are changing. Many changes are unprecedented over decades to millennia.
Climate models project continued changes under a range of possible greenhouse gas emission scenarios over the 21st century.[6]

Carbon dioxide is probably the most important of the greenhouse gases as it accounts for the largest proportion of the 'trace gases' and is currently responsible for 60% of the 'enhanced greenhouse effect'.

[4] UNESCO, United Nations Educational Scientific and Cultural Organization, Educating for a sustainable future, "A transdisciplinary vision for concerted action, 2007.
[5] The Fifth Assesment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC) is the most detailed assessment of climate change ever. It is based on more data, contains more detailed regional projection and it is more confident about its conclusion than any global assessment to date.
[6] Intergovernmental Panel on Climate Change (IPCC), The Fifth Assesment Report (AR5), 2014.

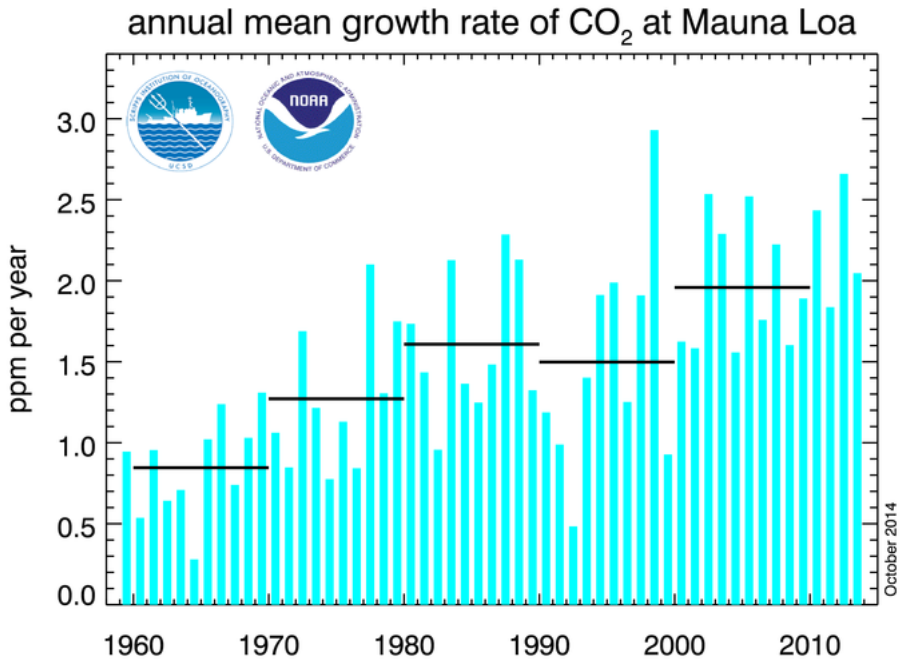


Figure 1: Annual mean growth rate of CO_2 at Mauna Loa. Data source: NOAA/ESRL

The graph clearly shows annual mean carbon dioxide growth rates for Mauna Loa. Based on the comparison of atmospheric samples contained in ice cores and more recent direct measurements, provides evidence that atmospheric CO_2 has increased since the Industrial Revolution.

Climate change has long-since ceased to be a scientific curiosity, and is no longer just one of many environmental and regulatory concerns. As the United Nations Secretary General has said, it is the major, overriding environmental issue of our time, and the single greatest challenge facing environmental regulators. It is a growing crisis with economic, health and safety, food production, security, and other dimensions.[7]

Observations, theoretical studies and model simulations indicate an overall warming since the mid-20th century. It is at least 95% certain that human activities have caused more than half of the temperature increase since the 1950s. This warming is responsible for climate change effects worldwide. There is strong

[7] http://www.unep.org/climatechange/Introduction.aspx

evidence that many of the changes taking place within the atmosphere, land, ocean, snow and ice systems are unprecedented over decades to millennia. The rising levels of greenhouse gases (particularly carbon dioxide) from the burning of fossil fuels and land-use changes (such as deforestation) are in large part driving warming. Natural processes (like changes in solar activity) are responsible for only a very small proportion of recent temperature changes.[8]

2.1.1 Sea level rise

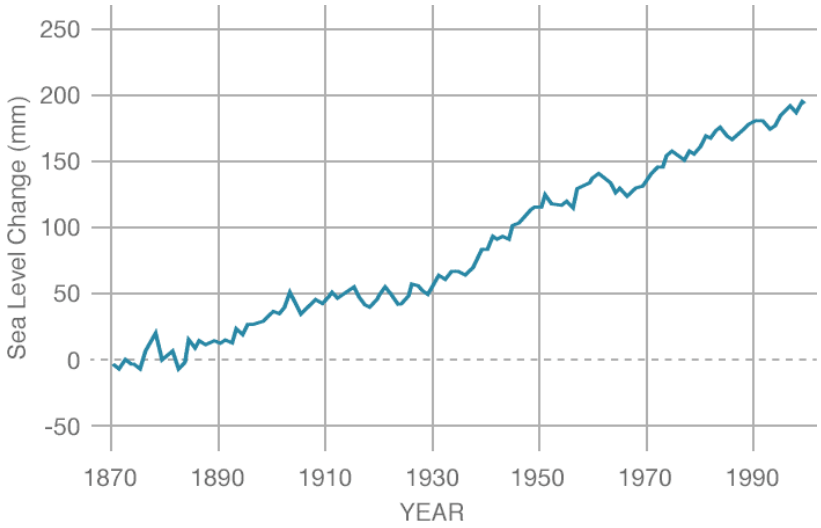


Figure 2: Sea level change. Data source: Coastal tide gauge records.

The chart (derived from coastal tide gauge data), shows how much sea level changed from about 1870 to 2000. The main causes of sea level rise over the past 50 years are ocean warming (water expands when it is warmed) and melting glaciers and ice sheets. The evidence is therefore that the rate at which global mean sea level is rising has accelerated over the past 200 years.

Climate change, evidently, affects all regions of the world, for this purpose, this chapter provides climate change information and evidence from various credible sources across the globe.

[8] Intergovernmental Panel on Climate Change (IPCC), The Fifth Assessment Report (AR5), 2014.

2.1.2 Global temperature rise

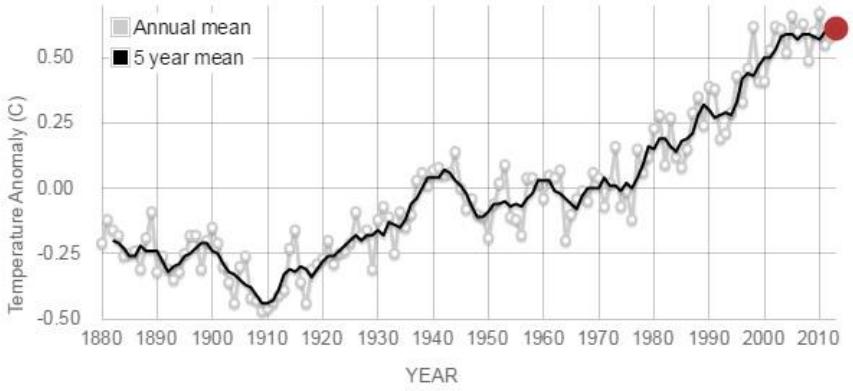


Figure 3: Temperature Anomaly. Data source: NASA/GISS.

Surface temperature over the land and ocean temperature is rising across the globe. This graph illustrates the change in global surface temperature relative to 1951-1980 average temperatures. The 10 warmest years in the 134-year record all have occurred since 1998, with 2010 and 2005 ranking as the warmest years on record.[9]

2.1.3 Warming oceans

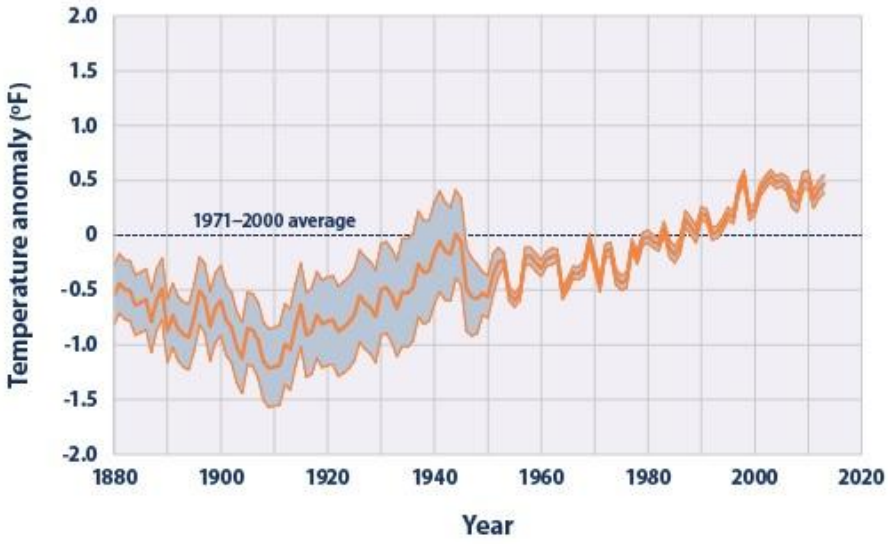


Figure 4: Temperature anomaly. Data source: NOAA.

[9] Source: NASA/GISS.

This graph shows how the average surface temperature of the world's oceans has changed since 1880. Sea surface temperature increased over the 20th century and continues to rise. From 1901 through 2013, temperatures rose at an average rate of 0.13°F per decade. Sea surface temperatures have been higher during the past three decades than at any other time since reliable observations began in 1880.[10]

2.1.4 Declining Arctic sea ice, glacial retreat and decreased snow cover

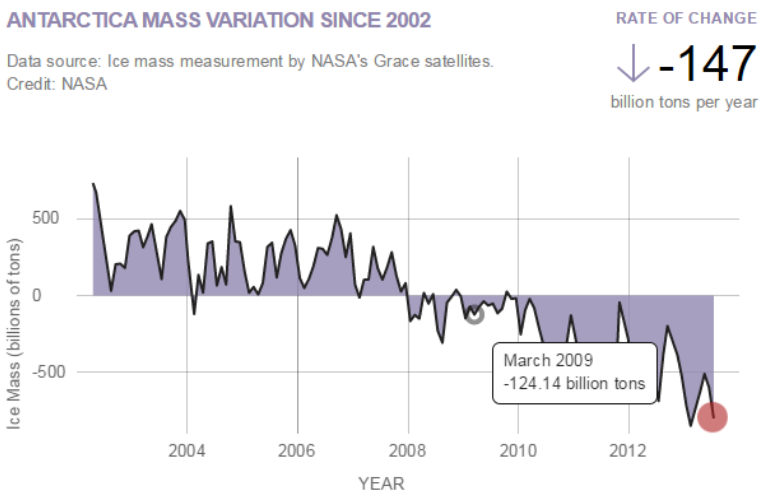


Figure 5: Antarctic Mass Variation since 2002. Data source: NASA.

Data from NASA's Grace Satellites show that the land ice sheets in both Antarctica is losing mass. The continent of Antarctica has been losing about 147 billion tons of ice per year since 2003.

[10] http://www.epa.gov/climatechange/science/indicators/oceans/sea-surface-temp.html

2.1.5 Extreme events

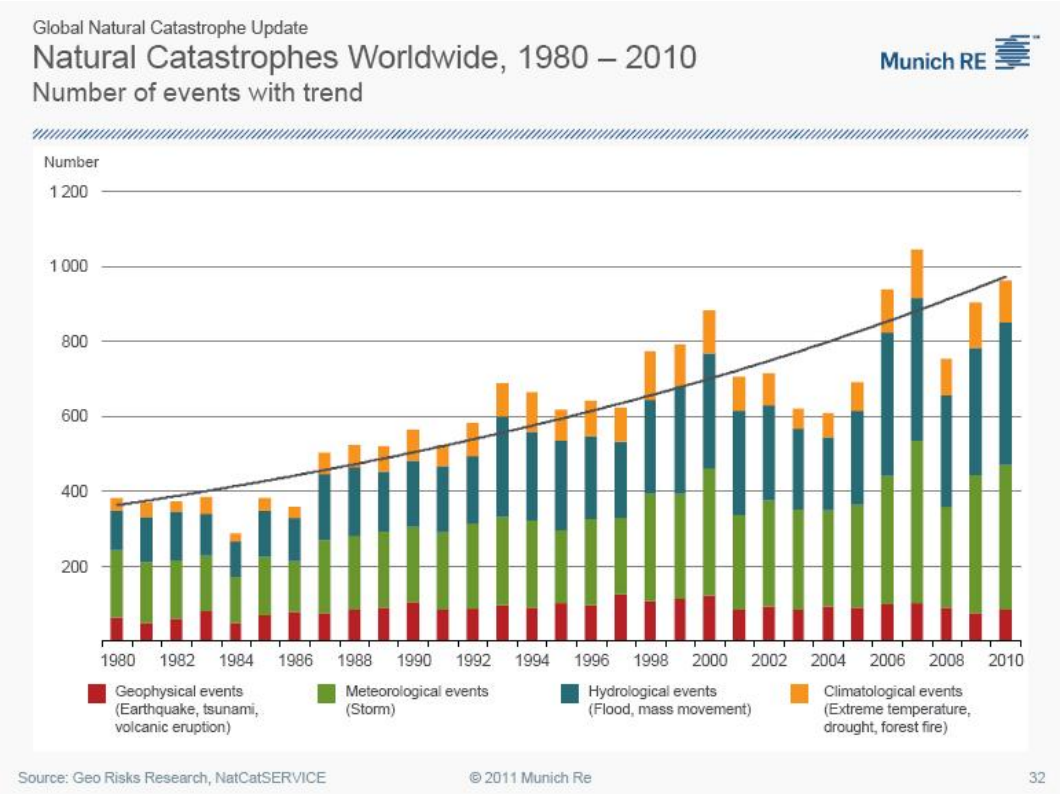


Figure 6: Extreme event. Data source: Geo Risks Research, NatCarSERVICE.

The graph over was recently published by Munich Re, one of the world's largest reinsurance companies. It clearly shows that natural catastrophes have increased substantially over the last 30 years with a trend line on the upswing.

2.1.6 Ocean acidification

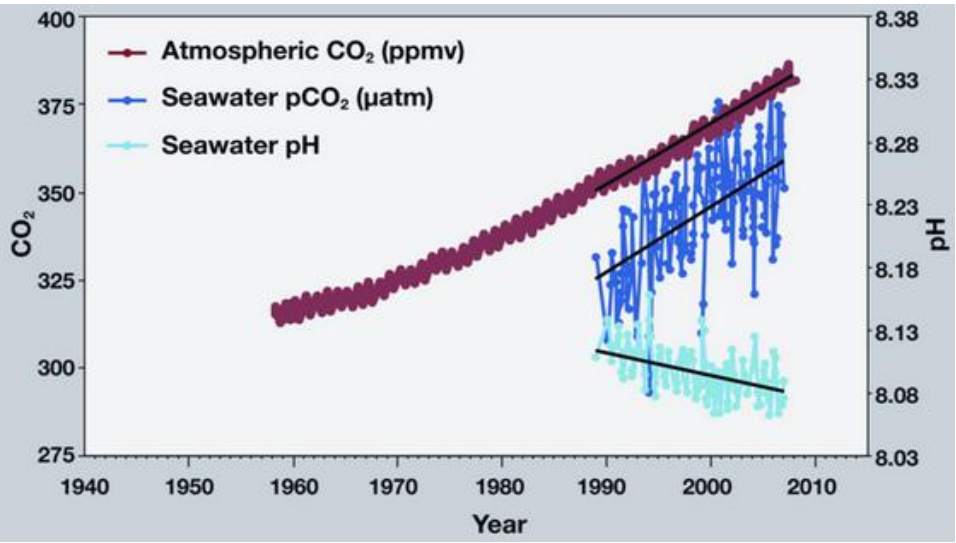


Figure 7: Time series of atmospheric CO_2 at Mauna Loa, surface ocean pH, and pCO_2 at Ocean Station ALOHA in the subtropical North Pacific Ocean. Data source: Doney et al., Annual Review of Marine Science, 2009.

This graph shows the correlation between rising level of carbon dioxide in the atmosphere at Mauna Loa with rising CO_2 levels in the nearby ocean at Station Aloha. As more CO_2 accumulates in the ocean, the pH of the ocean decreases.[11]

2.2 Human impact on the environment

Every living thing has an impact on its environment. Therefore a human impact on the environment is inevitable. By simply existing, all species - including ourselves - will imprint their mark on the world around them.

2.2.1 Water pollution and water scarcity

Perhaps the most obvious examples of a negative human impact on the environment is water pollution. It's obvious we need water to survive but few people realize how much we need and just how much is available.

[11] http://www.pmel.noaa.gov/co2/story/Ocean+Acidification

Water covers 70% of our planet, however, freshwater is incredibly rare. Only 3% of the world's water is fresh water, and two-thirds of that is tucked away in frozen glaciers or otherwise unavailable for our use.

As a result, some 1.1 billion people worldwide lack access to water, and a total of 2.7 billion find water scarce for at least one month of the year. Inadequate sanitation is also a problem for 2.4 billion people they are exposed to diseases, such as cholera and typhoid fever, and other water-borne illnesses. Two million people, mostly children, die each year from diarrheal diseases alone.

Many of the water systems that keep ecosystems thriving and feed a growing human population have become stressed. Rivers, lakes and aquifers are drying up or becoming too polluted to use. More than half the world's wetlands have disappeared. Agriculture consumes more water than any other source and wastes much of that through inefficiencies. Climate change is altering patterns of weather and water around the world, causing shortages and droughts in some areas and floods in others.

At the current consumption rate, this situation will only get worse. By 2025, two-thirds of the world's population may face water shortages. And ecosystems around the world will suffer even more.[12]

2.2.2 Air pollution

Air pollution is one such form that refers to the contamination of the air, irrespective of indoors or outside. A physical, biological or chemical alteration to the air in the atmosphere can be termed as pollution. It occurs when any harmful gases, dust, smoke enters into the atmosphere and makes it difficult for plants, animals and humans to survive as the air becomes dirty.

Air pollution can further be classified into two sections: visible air pollution and invisible air pollution. Another way of looking at air pollution could be any substance that holds the potential to hinder the atmosphere or the well being of the

[12] WWF, http://www.worldwildlife.org/threats/water-scarcity

living beings surviving in it. The sustainment of all things living is due to a combination of gases that collectively form the atmosphere; the imbalance caused by the increase or decrease of the percentage of these gases can be harmful for survival.

The Ozone layer considered crucial for the existence of the ecosystems on the planet is depleting due to increased pollution. Global warming, a direct result of the increased imbalance of gases in the atmosphere has come to be known as the biggest threat and challenge that the contemporary world has to overcome in a bid for survival.

The causes of Air pollution are:

- Burning of Fossil Fuels: Sulphur dioxide emitted from the combustion of fossil fuels like coal, petroleum and other factory combustibles is one the major cause of air pollution. Pollution emitting from vehicles including trucks, jeeps, cars, trains, airplanes cause immense amount of pollution. We rely on them to fulfil our daily basic needs of transportation. But, there overuse is killing our environment as dangerous gases are polluting the environment. Carbon Monoxide caused by improper or incomplete combustion and generally emitted from vehicles is another major pollutant along with Nitrogen Oxides, that is produced from both natural and manmade processes.
- Agricultural activities: Ammonia is a very common by product from agriculture related activities and is one of the most hazardous gases in the atmosphere. Use of insecticides, pesticides and fertilizers in agricultural activities has grown quite a lot. They emit harmful chemicals into the air and can also cause water pollution.
- Exhaust from factories and industries: Manufacturing industries release large amount of carbon monoxide, hydrocarbons, organic compounds, and chemicals into the air thereby depleting the quality of air. Manufacturing industries can be found at every corner of the earth and there is no area that has not been affected by it. Petroleum refineries also release hydrocarbons and various other chemicals that pollute the air and also cause land pollution.

- Mining operations: Mining is a process wherein minerals below the earth are extracted using large equipments. During the process dust and chemicals are released in the air causing massive air pollution. This is one of the reasons which are responsible for the deteriorating health conditions of workers and nearby residents.
- Indoor air pollution: Household cleaning products, painting supplies emit toxic chemicals in the air and cause air pollution.[13]

2.2.3 Solid and hazardous waste pollution

The increase in the global population and the rising demand for food and other essentials, there has been a rise in the amount of waste being generated daily. However, not all of this waste gets collected and transported to the final dumpsites. If at this stage the management and disposal is improperly done, it can cause serious impacts on health and problems to the surrounding environment.

Diseases are spread by uncollected garbage and blocked drains; the health risks from hazardous wastes are typically more localized, but often acute. Waters affect productivity through the pollution of groundwater resources.[14]

2.2.4 Soil degradation

Depleted soils increase the risks of malnutrition for farmers. Productivity losses on tropical soils are estimated to be in the range of 0.5-1.5 per cent of GNP, while secondary productivity losses are due to siltation of reservoirs, transportation channels and other hydrologic investments.

2.2.5 Deforestation

Forests cover 31% of the land area on our planet. They produce vital oxygen and provide homes for people and wildlife. Many of the world's most threatened and endangered animals live in forests, and 1.6 billion people rely on benefits forests offer, including food, fresh water, clothing, traditional medicine and shelter.

[13] http://www.conserve-energy-future.com/causes-effects-solutions-of-air-pollution.php
[14] The Paradigm Shift in International Social Development - Murli Desai.

Deforestation comes in many forms, including fires, clear-cutting for agriculture, ranching and development, unsustainable logging for timber, and degradation due to climate change. This impacts people's livelihoods and threatens a wide range of plant and animal species. Some 46-58 thousand square miles of forest are lost each year—equivalent to 36 football fields every minute.

Death and disease can result from the localized flooding caused by deforestation. Loss of sustainable logging potential and of erosion prevention, watershed stability and carbon sequestration provided by forests are among the productivity impacts of deforestation.[15]

2.2.6 Loss of biodiversity

Habitat loss, degradation, exploitation (through hunting and fishing) are the first causes of the decline in biodiversity. The extinction of plant and animal species will potentially affect the development of new drugs; it will reduce ecosystem adaptability and lead to the loss of genetic resources.

The Living Planet Index (LPI), which measures trends in thousands of vertebrate species populations, shows a decline of 52 per cent between 1970 and 2010. In other words, the number of mammals, birds, reptiles, amphibians and fish across the globe is, on average, about half the size it was 40 years ago. This is a much bigger decrease than has been reported previously, as a result of a new methodology which aims to be more representative of global biodiversity.

Terrestrial LPI

Terrestrial species declined by 39 per cent between 1970 and 2010, a trend that shows no sign of slowing down. The loss of habitat to make way for human land use – particularly for agriculture, urban development and energy production – continues to be a major threat, compounded by hunting.

Freshwater LPI

The LPI for freshwater species shows an average decline of 76 per cent. The main threats to freshwater species are habitat loss and fragmentation, pollution and

[15] http://www.worldwildlife.org/threats/deforestation

invasive species. Changes to water levels and freshwater system connectivity – for example through irrigation and hydropower dams – have a major impact on freshwater habitats.

Marine LPI

Marine species declined 39 per cent between 1970 and 2010. The period from 1970 through to the mid-1980s experienced the steepest decline, after which there was some stability, before another recent period of decline. The steepest declines can be seen in the tropics and the Southern Ocean – species in decline include marine turtles, many sharks, and large migratory seabirds like the wandering albatross.[16]

2.3 Future climate change

Climate change over the next few decades is largely governed by levels of greenhouse gases already in the atmosphere. The amount of mitigation action assumed in scenarios has little impact in the near-term.

In contrast, the trajectory of greenhouse gas emissions (which mainly depends on policy choices made by governments) has a major impact on climate change projected for the mid-21st century and onwards. Although the results from the climate models vary, they all indicate that emissions at or above current rates would cause changes in all parts of the climate system, some unprecedented in thousands of years. The changes would occur in all geographical regions, and many would continue for hundreds or thousands of years even if emissions were cut to zero.

There is some debate as to whether human influence could trigger an abrupt change in climate, or even force parts of the climate system across critical thresholds or 'tipping points', causing irreversible change. Although scientific studies suggest such events are possible, there is little agreement on how likely they are in the 21st century or what the human consequences would be.

[16] Living Planet – Report WWF 2014.

In conclusion, the image below shows how all Climate indicators (Ocean pH, CO2 concentration, etc.) have a strong impact on all types of business (Manufacturing, Farming, etc.) and at the same time the impacts and risks of Business have an influence on Climate indicators, thus triggering a vicious circle.

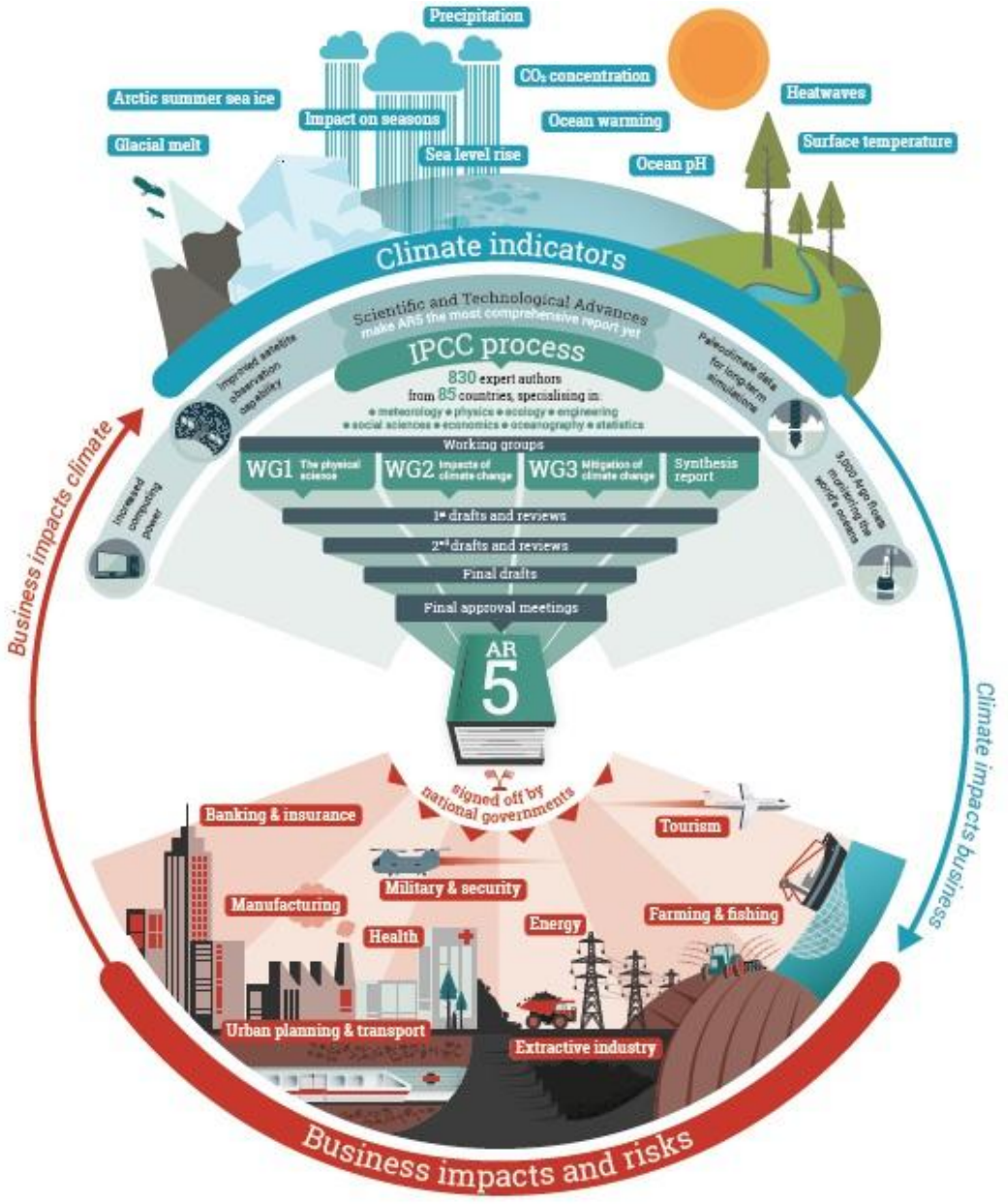


Figure 8: IPCC Process AR5 Info graphic.

3 Sustainability and sustainable development

Sustainable development has been defined in many ways, but the most frequently quoted definition is from Our Common Future, also known as the Brundtland Commission:

> "Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs"

The Commission further defined two key concepts of sustainable development: (1) needs, specifically the essential needs of those living in poverty; and (2) limitations, specifically those imposed by technology and social structures on the environment's ability to meet present and future needs. The approach is thus one that aims to meet human needs, including those of future generations, while also protecting the environment.

This statement of sustainable development is one which we would probably all endorse. It captures the key temporal prerequisite of sustainability – persistence into the long-term future – through its explicit reference to intergenerational equity. On the other hand, the Brundtland formulation can be seen as enigmatic as well as emblematic – by expressing a qualified consensus reached by a UN Commission charged with reconciling the goals of environmental protection and economic growth it epitomises the contestability of the territory. The price of consensus commonly is ambiguity; the positive aspect is that ambiguity can encourage discussion and debate, an essential part of the practical process of working towards sustainability.[17]

The terms "sustainability" and "sustainable development" have been used interchangeably above, the following distinction offers a useful guide:

[17] Diesendorf, M., Sustainability and sustainable development, in Sustainability: The corporate challenge of the 21st century, 2000.

Sustainability is the ultimate goal or destination. Exactly what defines the state of being, of what is sustainable (whether it be a society, logging, fishing etc), is informed by science but ultimately depends on personal values and world views.

To achieve a state of environmental sustainability, a framework or process is needed. Certain conditions have to be met and steps in the process toward 'sustainability' have to be made. The framework of sustainable development is the means for achieving sustainability.

So, in brief, "sustainability" refers to the goal and "sustainable development" is the path or framework to achieve it. As with the term "sustainability", what is considered as a necessary path and time frame will vary amongst individuals.

Further, it must be emphasised that development is not synonymous with growth. Growth is about becoming quantitatively bigger; development on the other hand is about becoming qualitatively better.[18]

Sustainable development, then, may be defined as the intentional means whereby humans strive towards sustainability, the co-evolution of human and natural systems to enable adaptation to change indefinitely, which:

- Is based on qualitative development/improvement, not quantitative growth;
- Conserves and enhances natural capital stocks, which cannot sustainably be substituted by other forms of capital;
- Combines social equity in improving present quality of life with intergenerational equity in meeting the needs of the future; and
- Acknowledges cultural development and cultural diversity (as with biodiversity) as central to the adaptive process of realising sustainability.

[18] Daly, H.E., Beyond Growth: The Economics of Sustainable Development, 1996.

Future sustainable development agenda

At the turn of the century, world leaders came together at the United Nations and agreed on a bold vision for the future through the Millennium Declaration. The Millennium Declaration and the Millennium Development Goals (MDGs) have successfully focused world attention and action on ending extreme poverty in all its forms and reducing gender inequality. The fifteen-year MDG period will be completed at the end of 2015. The Rio+20 Summit in June 2012 resolved to finish the job of ending extreme poverty and hunger as a matter of urgency. It also endeavoured to place poverty reduction within the broader context of sustainable development. The summit's final outcome document, The Future We Want, calls for new Sustainable Development Goals (SDGs), including the eradication of poverty and hunger. It also launched an intergovernmental Open Working Group to make recommendations to the UN General Assembly on the design of these goals.[19]

It is evident that now sustainability is not only a goal to reach but now is the main container of targets, to be known as the Sustainable Development Goals (SDGs), are defining the way forward on the world's most pressing issues until the next critical deadline in 2030.

[19] Leadership Council of the Sustainable Development Solutions Network: An Action Agenda for Sustainable Development, REPORT FOR THE UN SECRETARY-GENERAL, 2013.

Figure 9: Sustainable development goals. Credits: Sustainable development goals UN website.

The 17 new SDGs, crafted by a working group of the 193-member UN General Assembly and expected to be adopted by world leaders in September 2015, have pushed sustainability and the fight against climate change to the forefront of the UN agenda. Twelve of the 17 goals underscore the importance of sustainable development in key areas, from urban planning to economic growth, while acknowledging the need to take "urgent action to combat climate change and its impacts" across the planet.[20]

3.1 The four capitals and the four bottom lines

Ecological economists generally recognize four distinct "capitals" which are necessary to support the real, human welfare producing economy:

[20] United Nation News Centre - Climate change and sustainability key to future development agenda, says former UN official, 2015.

- Natural (the land, sea, air and ecosystems from which the human economy derives its materials and energy and to which it ultimately returns its wastes);
- Built (buildings and cities, the physical infrastructure which produces economic outputs and the human artifacts thus obtained);
- Human (the health, skills, knowledge and values of the human population); and
- Social (the web of formal and informal interpersonal connections and institutional arrangements which facilitate human interactions).

This taxonomy provides a useful model to help articulate the structures, processes and relationships which are fundamental to the transition to sustainability.

The expectation of tripartite satisfaction of economic, environmental and social goals referred to above can also be expressed in terms familiar to the business world; the triple bottom line refers to satisfaction of not just the acknowledged bottom line of meeting economic goals (profits) but also the need to now simultaneously meet environmental and social goals (or "bottom lines") in carrying out their business. This also provides a practical framework for the development of policies and strategies to drive institutional change. When the objective is transformation rather than mere observation, the rationale for including governance as a fourth bottom line is reinforced. Governance is defined in the present context to include both the formal regulatory, business administrative and political processes of the university which determine or influence decision-making and action, and the informal networks, traditions and cultural and behavioral norms which act as enablers or disablers of sustainable development.

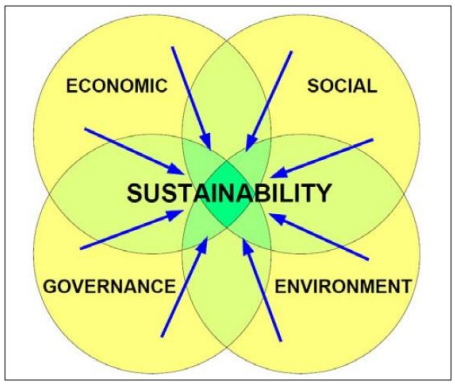


Figure 10: The quadruple bottom line

4 The role of university

University can play a significant role in forging the path to a sustainable future. By their nature, universities are focused on research, teaching and service and as an institution, they are tasked with training the world's future leaders. As universities' mission and activities are not directly tied to financial or political gain, they have the capacity to test system and technologies, and to advance innovative solutions to global challenges in ways that companies and municipalities cannot. [21]

University, the training area for future leaders has a specific responsibility to move society towards a sustainable future. Cocoran, Calder, and Clugston (2002, 99) expressively state:

> "College and university are vested by society with the task of discerning truth, imparting values, and socializing students to contribute to social progress and the advancement of knowledge. They have a profound responsibility to impart the moral vision and technical knowledge needed to ensure a high quality of life for future generations. Sustainable development is the current context in which higher education must focus its mission".

In this context, sustainable development is one of the biggest challenges of the twenty-first century. Several universities have begun the debate about the content of this concept and the ways in which to integrate it to their university policy, organization and activities.

There are many ways in which universities can be involved in sustainable development, e.g. management, planning, development, education, research, operations, community service, purchasing, transportation, design, new construction, renovation and retrofit. In engaging with the issue, a university may have a particular focus, a programme or even a holistic mission.

[21] Green Guide for Universities – Pathways towards sustainability – International Alliance of Research Universities (IARU).

Basically, a university is an organization with a purpose that it fulfils by implementing programmes within the context of the operation of faculties, possibly located on a campus. [22]

4.1 Responsibility of university

University in all countries bear a special responsibility with regard to sustainability, for the following reason:

- Higher Education as the 'nursery of tomorrow's leaders'

  "Universities educate most of the people who develop and manage society's institutions. For this reason, universities bear profound responsibilities to increase the awareness, knowledge, technologies, and tools to create an environmentally sustainable future."[23]

This clearly implies that graduates of every discipline (whether as engineers, teachers, politicians, lawyers, architects, biologists, bankers, managers, or tourist operators, etc.) will need a sound working knowledge of sustainability.

- Universities as a role models for society:

  Universities are – rightly or wrongly – regarded as the centres of the most advanced knowledge. They should, therefore, through their teaching and their institutional practice, embody role models of excellence and microcosms of best practices for the future. [24]

[22] H van Weenen , Towards a vision of a sustainable university.
[23] Talloires Declaration, 1995
[24] Cortese, A.D., Education for Sustainability: The University as a Model of Sustainability. Second Nature,1999.

- Universities enjoy special status which incurs special obligation to society:

> "Higher education institutions are allowed academic freedom and a tax-free status to receive public and private resource".[25] Society rightly expects universities, in exchange for this privileged position, to contribute as much as possible to the solution of society's problems. [26]

Therefore, education must play a central role in making the transition to sustainability. If the leaders of tomorrow do not make sustainability a central academic and organizational focus, it will be impossible to create a just, equitable, and sustainable future. This includes the development of our understanding of sustainability through policymaking, capacity-building, technology transfer, and science, and research. There is no doubt that universities play a more crucial role than other institutions in fulfilling this responsibility.

In conclusion education is humanity's best hope, according to UNESCO, education serves society in a variety of ways:

> "The goal of education is to make people wiser, more knowledgeable, better informed, ethical, responsible, critical and capable of continuing to learn. Were all people to possess such abilities and qualities, the world's problems would not be automatically solved, but the means and the will to address them would be at hand. Education also serves society by providing a critical reflection on the world, especially its failings and injustices, and by promoting greater consciousness and awareness, exploring new visions and concepts, and inventing new techniques and tools. Education is also the means for disseminating knowledge and developing skills, for bringing about desired changes in behaviours, values and lifestyles, and for promoting public support for the continuing and fundamental changes that will be required if humanity is to alter its course, leaving the familiar path that is leading towards growing difficulties and possible catastrophe, and starting the uphill climb towards sustainability. Education, in short, is

[25] Cortese, A.D., Education for Sustainability: The University as a Model of Sustainability. Second Nature,1999.
[26] Rolf Jucker ,A Vision for sustainable University.

humanity's best hope and most effective means in the quest to achieve sustainable development".[27]

Therefore, universities have a special responsibility to take over leading position by demonstrating best practices that sustain and educating a sustainable society. Universities have the opportunity to create culture of sustainability for today's student, and to set their expectations for how the world should be.

4.2 Sustainable university

In general terms, a university consciously choosing the path of sustainable development would exemplify the following principles:

- Clear articulation and integration of social, ethical and environmental responsibility in the institution's vision, mission and governance;

- Integration of social, economic and environmental sustainability across the curriculum, commitment to critical system thinking and interdisciplinary, sustainability literacy expressed as a universal graduate attribute;

- Dedicated research on sustainability topic;

- Outreach and service to the wider community, including partnership with school, government, non-governmental organizations and industry;

- Campus planning, design and development structured and managed to achieve and surpass zero net carbon/water/waste, to become a regenerative organization within the context of the local bioregion;

- Physical operations and maintenance focused on supporting and enabling "beyond zero" environmental goals, including effective monitoring, reporting and continual improvement;

[27] UNESCO, United Nations Educational Scientific and Cultural Organization, Educating for a sustainable future, "A transdisciplinary vision for concerted action, 2007.

- Policies and practices with foster equity, diversity and quality of life for student, staff, and the broader community within which the university is based;

- The campus as a "living laboratory" – student involvement in environmental learning to transform the learning environment;

- Celebration of cultural diversity and application of cultural inclusivity; and

- Framework to support cooperation among universities both nationally and globally.

Universities by definition have accepted the challenge of leadership and aspiration to best practice, in the creation and dissemination of knowledge. The transition to sustainability opens up new challenges, but also tremendous opportunities. Governments, businesses, NGOs and individuals – and a growing number of universities – have already made significant progress, and the road ahead is well illuminated in terms of tested and evidenced strategies.[28]

4.2.1 Sustainability issues, risks and associated challenges in universities

Universities are complex, multi-faceted entities with diverse organisational subcultures, traditions and concerns[29], and the transitory nature of university life for the bulk of the campus community can mean the real impacts of the institution remain unacknowledged[30]. There may be individual high quality initiatives aimed at addressing these impacts, but where these are restricted to one or a handful of organisational units they inevitably end up ad hoc and uncoordinated. In addition, limited funding and multiple calls on capital budgets favour short-term fixes over green investments with long-term paybacks. Staff and students have heavy

[28] Green Guide for Universities – Pathways towards sustainability – International Alliance of Research Universities (IARU)
[29] Sharp, L., Green campuses: the road from little victories to systemic transformation. International Journal of Sustainability in Higher Education, 2002.
[30] Flint, K., Institutional ecological footprint analysis: A case study of the University of Newcastle, Australia. International Journal of Sustainability in Higher Education, 2001.

workloads; limited time and multiple expectations as to how that time is used can make it problematic to initiate, maintain, complete and evaluate projects, and compound natural resistance to change. Moreover, universities generally lack the incentive structures necessary to promote changes at the individual level.[31]

In discussing the issues, risks and challenges of university sustainability it is helpful to separately review the "triple bottom line" dimensions of environment, economy and society / culture, recognising both their inter-relationships, and the crucial role of the fourth "bottom line" – governance– across these three dimensions.

Environmental

Universities embody the environmental issues, risks and challenges of the wider communities in which they are situated, but also express their own unique characteristics. On one level, a university may be likened to a small town, with all the associated issues of spatial planning, management of physical growth and development, maintenance of buildings and open spaces, supply of electricity, water and other utilities, and often provision of residential accommodation and ancillary services. In addition, there are the typically corporate functions of finance, procurement, human resources, etc.

However, the distinguishing feature of a university is its core purpose of teaching, research and community outreach. This generates a plethora of distinctive environmental issues on top of those typical of the small town or the corporate office, which often include significant (indeed semi-industrial) levels of resource consumption, carbon emissions, waste and pollution. Risks here include the reputational and financial – linked to legal compliance – which on their own are enough to motivate some institutions towards sustainable development. The broader challenge is to minimise the legally compliant but environmentally unsustainable impacts of the university's activities while maintaining and extending its teaching / research / outreach core.

[31] Ferrer-Balas, D., et al., An international comparative analysis of sustainability transformation across seven universities. International Journal of Sustainability in Higher Educatiob, 2008.

Economic

Universities are major employers, major investors and major purchasers of goods and services. There are opportunities across all these areas for intervention, in terms of direct and indirect support for local jobs, ethical/ sustainable investment and "green" procurement strategies which can help integrate sustainability along the supply chain (for example by specifying standards of environmental performance in tender documentation). One challenge common across many nations is a declining level of public funding. Cost is a significant factor in most sustainability investment, and in some cases may appear insurmountable. However, even in situations where natural disaster or difficult economic conditions limit university budgets to the minimum necessary to keep their doors open, options to address sustainability imperatives are available. Typically these will involve the capture of savings around management of the key flows (inputs and outputs) of energy, water and materials, which can provide a buffer for future capital and operational investment in sustainability initiatives.

The risk is that senior management may welcome the savings, but be reluctant to channel any (let alone all) into new greening endeavours, thereby relinquishing the opportunity for continual improvement. The key here is management buy-in – which means a shift from a "command and control" mentality to a shared vision.

Socio-cultural

The socio-cultural dimension of sustainability needs to be considered at two levels: internally with respect to the university's own formal and informal organisational structures; and externally with respect to the university's relationships with the wider community. Regarding the former, the key issue is gaining support and commitment from students, academic staff, operational staff and senior management, groups whose motivations, priorities and ways of thinking and doing may be on some issues not just unaligned, but diametrically opposed.[32]

[32] UNEP, Greening Universities Toolkit: Transforming universities into green and sustainable campuses, 2013.

4.2.2 Exemplary cases

Universities are achieving increasing alignment between their real estate and research findings, whether these relate to new technology or requirements for sustainable development. As a world's first, École polytechnique fédérale de Lausanne is installing large scale solar windows at its new SwissTech convention center, demonstrating the potential of translucent "Graetzel solar cells" that can be deployed vertically and that are based on research at that school. And Ball State University expects to be able to cut its campus carbon footprint nearly in half once its campus-wide heating and cooling system currently under development is fully operational.

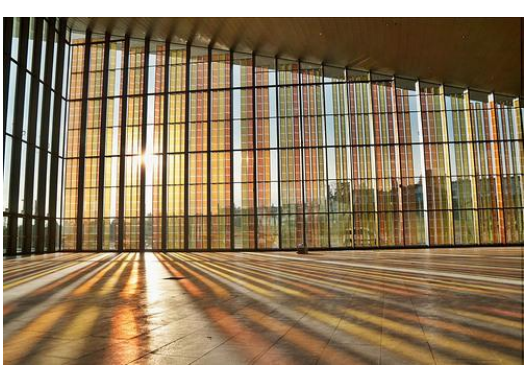


Figure 11: École polytechnique fédérale de Lausanne "Graetzel solar cells".

Figure 12: Ball State University "District Energy Station North".

In a project similar to a recent development at ETH Zurich, connecting all of Ball State's 47 campus buildings with a geothermal grid will allow optimization by "trading" energy needs between them.

Successful sustainable design is strongly context-dependent. The major new "UTown campus" development of National University of Singapore illustrates an approach suited to tropical climates that combines high-tech features with a design focus on optimizing natural ventilation. Together with behavioural incentives like pay-as-you-go student residence air-conditioning, energy use and related costs can be reduced significantly.

Figure 13: National University of Singapore "UTown campus".

A very different kind of context applies to campuses that include a large proportion of historic construction. Illustrating that also historic buildings are amendable to high-efficiency upgrades, University of Oxford cut the energy consumption of the protected building that hosts its Institute of Archaeology in half. Motion sensors, daylight sensors, and efficient wireless light switches that don't impact on the building's fabric have contributed to this balance of preservation and efficiency. Contextual challenges can also stem from a buildings function, like for MIT's David H. Koch Institute for Integrative Cancer Research. Focused on interdisciplinary work, the building has to accommodate the different laboratory demands of both engineers and biologist. Nevertheless, this first Leadership in Energy and Environmental Design (LEED) Gold certified research laboratory at MIT achieved significant energy use reductions for example via a cascading ventilation system where air used to cool offices is reused for the hoods in lab areas.

Finally, ambitious goals for enhanced teaching and learning spaces, public facilities, open landscape and convenient access had to be addressed on a steep and narrow hillside location for the LEED Platinum-certified Centennial Campus development at the University of Hong Kong. Models like this for sustainability in the built environment are essential contributions to public sustainability debates in cities and regions that are densely populated, face severe environmental stress, and still show strong dependency on coal or other fossil fuel for electricity.[33]

[33] UNEP, Greening Universities Toolkit: Transforming universities into green and sustainable campuses, 2013

Figure 14: LEED Platinum-certified.

4.3 Sustainable University Network

One of principles already listed consist in support cooperation among universities both nationally and globally, for this purpose, this paragraph give a forward about sustainability and its network.

There are different networks that support major institutions, universities and corporate campuses that allow the exchange of information, ideas and best practices to achieve concretely the development of sustainable campus. Below are described the two major worldwide network and subsequently an example of European campus network with campuses functioning as regional climate innovation engines.

4.3.1 International Sustainable Campus Network (ISCN)

The mission of the International Sustainable Campus Network (ISCN) is to provide a global forum to support leading colleges, universities, and corporate campuses in the exchange of information, ideas, and best practices for achieving sustainable campus operations and integrating sustainability in research and teaching.

The ISCN is managed by the network's Secretariat, operated by Sustainserv Inc., and its strategic development is guided by a Steering Committee including representatives of the five schools who generously host the ISCN: EPF Lausanne;

ETH Zurich; Nanyang Technological University; National University of Singapore; The University of Hong Kong.

Building on and complementing initiatives on the local, regional, and national level, the ISCN has created a nested hierarchy of principles as key focal points of international exchange. The ISCN approaches these issues with an integrated strategy featuring the following programs.

ISCN-GULF Sustainable Campus Charter

Institutions may sign the charter and commit to set their own, concrete targets against shared Charter principles mentioned above, and to report transparently on their progress against those targets.

The Charter structures campus commitments about sustainability into a nested hierarchy encompassing individual buildings, campus-wide planning and target setting, and integration of research, teaching, outreach and facilities for sustainability. Three corresponding principles are the core of the Charter.

Furthermore, in order to measure the actual performance in compliance with these principles, the ISCN Charter Report proposes GRI[34] and STARS[35] related indicators.

[34] The Global Reporting Initiative (GRI) is a non-profit, multi-stakeholder organization that strives to provide companies and other organizations with a systematic basis for disclosure regarding sustainability performance. The aim is to give stakeholders a framework that facilitates comparison and understanding of disclosed information. GRI developed also sectoral guidelines for reporting, including for major industrial sectors, as well as for public agencies. Alone in 2009, more than 1,300 companies and public agencies have published sustainability reports based on the GRI framework.

[35] The Sustainability Tracking, Assessment & Rating System (STARS) has been developed by the Association for the Advancement of Sustainability in Higher Education (AASHE) as a transparent self-reporting framework for North-American colleges and universities to gauge relative progress toward sustainability. It is intended to cover the full spectrum from community colleges to research universities, and from institutions just starting their sustainability programs to long-time campus sustainability leaders.

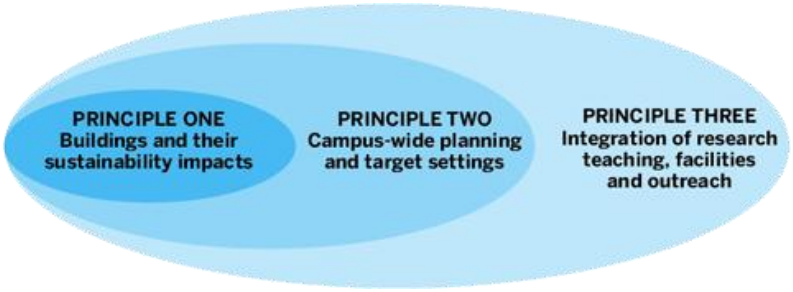


Figure 15: International Sustainable Campus Network Principles.

Principle one: Sustainability performance of building on campus

> "To demonstrate respect for nature and society, sustainability considerations should be an integral part of planning, construction, renovation, and operation of building on campus.
>
> A sustainable campus infrastructure is governed by respect for natural resources and social responsibility, and embraces the principle of a low carbon economy. Concrete goals embodied in individual buildings can include minimizing environmental impacts (such as energy and water consumption or waste), furthering equal access (such as non-discrimination of the disabled), and optimizing the integration of the built and natural environments. To ensure building on campus can meet these goals in the long term, and in a flexible manner, useful processes include participatory planning (integrating end-users such as faculty, staff, and students) and life-cycle costing (taking into account future cost-savings from sustainable construction)."

Principle two: Campus-wide master planning and target setting

> "To ensure long-term sustainable campus development, campus-wide master planning and target-setting should include environmental and social goals.
>
> Sustainable campus development needs to rely on forward-looking planning processes that consider the campus as a whole, and not just individual buildings. These processes can include comprehensive master planning with goals for impact management (for example, limiting use of

land and other natural resources and protecting ecosystem), responsible operation (for example encouraging environmentally compatible transport modes and efficiently managing urban flows), and social integration (ensuring user diversity, creating indoor and outdoor spaces for social exchange and shared learning, and supporting ease of access to commerce and services). Such integrated planning can profit from including users and neighbours and can be strengthened by organization-wide target setting (for example greenhouse gas emission goals). Existing low carbon lifestyle and practices within individual campuses that foster sustainability, such as easy access for pedestrian, grey water recycling and low levels of resource use and waste generation, need to be identified, expanded and disseminated widely".

Principle three: Integration of facilities, research, education, and outreach as a "living laboratory" for sustainability

> "To align the organization's core mission with sustainable development, facilities, research, and education should be linked to create a "living laboratory" for sustainability.
>
> On a sustainable campus, the built environment, operational system, research, scholarship, and education are linked as a "living laboratory" for sustainability. Users (such as students, faculty and staff) have access to research, teaching, and learning opportunities on connections between environmental, social, and economic issues. Campus sustainability programs have concrete goals and can bring together campus resident with external partners, such as industry, government, or organized civil society. Beyond exporting a sustainable future in general, such programs can address issues pertinent to research and higher education (such environmental impacts of research facilities, participatory teaching, or research that transcends disciplines). Institutional commitments (such as a sustainable policy) and dedicated resources (such as a person or team in the administration focused on this task) contribute to success."[36]

[36] Global University Leaders Forum (GULF), International Sustainable Campus Network (ISCN), Implementation Guidelines to the ISCN-GULF Sustainable Campus Charter

Working Groups

Working groups dedicated to each of the 3 Charter Principles, conduct research and facilitate the development of resources to support knowledge exchange.

Conferences and Symposia

Conference and Symposia are held across the globe to address the whole breadth of campus sustainability or focus more closely on particular issues of strategic relevance for campus sustainability.

Sustainable Campus Excellence Awards

The International Sustainable Campus Excellence Awards recognize sustainable campus projects that demonstrate leadership, creativity, effectiveness and outstanding performance in the areas of Building, Campus, Integration and Student Leadership. The Awards are given out annually to highlight best practices and provide public recognition to campuses excelling in campus sustainability.[37]

For instance, the ISCN Student Leadership is given to outstanding student projects or campaigns contributing to the sustainable campus and encouraging other students to start their own initiatives to make a difference. The 2014 winner of the student leadership award is the University of Exeter with "Students' Green Unit" that consist in a professional unit empowering students to shape sustainability through behaviour change.

4.3.2 International Alliance of Research Universities (IARU)

The International Alliance of Research Universities (IARU), established in 2006, is a collaboration between ten of the world's leading research-intensive universities. The members are the Australian National University, ETH Zurich, National University of Singapore, Peking University, University of California, Berkeley, University of Cambridge, University of Copenhagen, University of Oxford, the University of Tokyo and Yale University.

[37] http://www.international-sustainable-campus-network.org/

The ten universities share similar values, a global vision and a commitment to educating future world leaders. Central to these values is the importance of academic diversity and international collaboration.

IARU member universities work together to address the major challenges of our time. Sustainable solutions on climate change is one of its key initiatives. As part of their commitment to promote sustainability, the IARU universities have established a Campus Sustainability Program, aimed at reducing the environmental impact of their campuses. IARU successfully organized an International Scientific Congress on Climate Change in 2009 and a Sustainability Congress in 2014. Some of its members also cooperate on major research projects pertaining to aging, longevity and health, global security and sustainable cities.

IARU seeks to add value by providing opportunities to students and staff that would not arise otherwise. The Alliance has developed a set of global education initiatives aimed at cultivating a sense of global citizenship and leadership amongst students. The Global Summer Program, the Sustainability Fellowships and internships offer opportunities to students of the IARU member universities to engage critically as global citizens in an increasingly interconnected world.

IARU promotes institutional joint working on various levels of the member universities, such inter-university networking, institutional learning and staff development. Projects cover a broad range of topics, ranging from equal opportunities, technology transfer, technology-enhanced learning, research administration, libraries and open access.[38]

4.3.3 Sustainable Campus Launching Customer example

The project Sustainable Campus Launching Customer (SCLC) presents sustainable transition initiative developed by several European Campus in the framework of the European Institute of Innovation & Technology Climate-KIC Program.[39] The pathfinder project SCLC aims to bridge the societal demand for

[38] http://www.iaruni.org/
[39] Francesca Cappellaro, A Pan-European Campus Network as regional Climate Innovation Engines, 2014.

climate innovation and the scientific knowledge supply from a network of nine European university campuses.[40]

The project ‘Sustainable Campus Launching Customer’ confirms universities have ambitions to play a key role in climate innovation being a regional climate innovation engine.

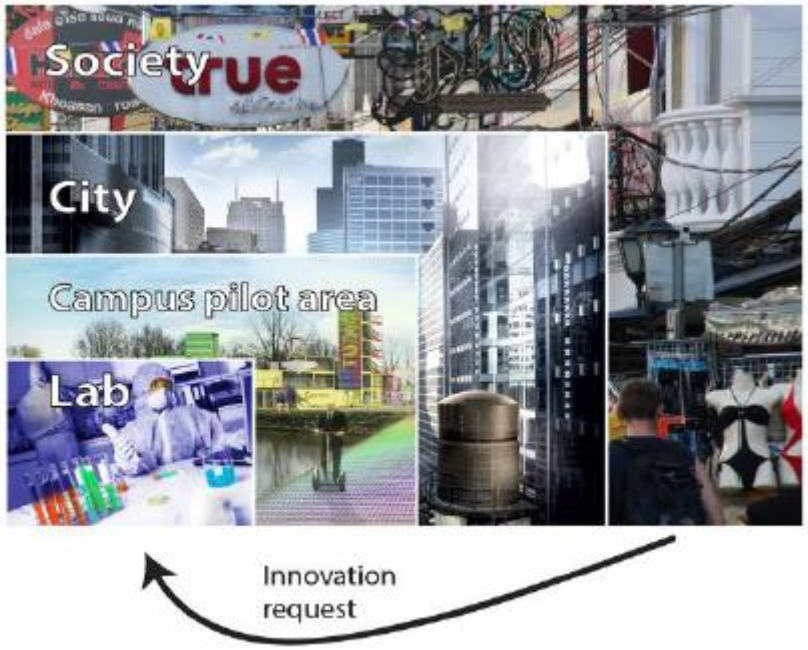


Figure 16: SCLC Project "The campus as a regional sustainable innovative engine".

A known discussion is the effectiveness of a ‘technology push’ versus a ‘demand pull’ innovation model. The current status quo seems to be technology push model, where this project aims to open-up the campus community to work on societal demand as input for research question to be tested in the lab, at campus and subsequently implemented back into city and society.[41]

SCLC is the pathfinder for the future SUCCESS project that will be described in the following chapters.

[40] http://www.climate-kic.org/projects/sustainable-campus-launching-customer/
[41] Francesca Cappellaro, A Pan-European Campus Network as regional Climate Innovation Engines, 2014.

5 How Delft University of Technology and University of Bologna face the challenge of sustainability

After setting out a general framework on current environmental issues, sustainable development and the universities role in sustainability, the aim of this chapter is to formalize a general overview of the university, a description of sustainability strategies in terms of commitment and best practices through the methodology proposed by ISCN. Additionally, the sustainability goals and initiatives are detailed in terms of key issues and performances.

5.1 Methodology

Through the use of guidelines drawn from The Sustainable Campus Charter[42] that provides universities and corporations a common framework to formalize their commitment and goals on campus sustainability this work tries to analyze how TU Delft University of Technology and University of Bologna face the challenge of campus sustainability.

The ISCN principles represent the commitment that both universities should implement in order to become a sustainable university. In particular this work aims to analyze in detail the Principle one and the Principle two in order to highlight which key performance indicators are essential to reach sustainability in particular will be study the following aspect:

- Energy use;
- Water use;
- Solid waste and Recycling;
- Carbon emission.

Consequently, through a SWOT analysis (a method used to evaluate strength, weaknesses, opportunities and threats involved in both universities) both universities are studied in terms of sustainability. The analysis is useful to find

[42] The Sustainable Campus Charter has been developed and is disseminated in collaboration between the International Sustainable Campus Network ISCN and the Global University Leader Forum GULF convened by the World Economic Forum.

their competitive advantage in order to address the issue of transfer knowledge from side to side.

Furthermore, the third principle is analyzed in the last part of this work, in a perspective of partnership and networking between universities, through the development of a European project called SUCCESS!

5.1.1 Aspect: Energy, Water, Waste, Carbon Emission

The Aspects that will be covered in the analysis Indicator set are structured to reflect the inputs, outputs, and model of impact a university has on the environment. In particular will be studied Energy, Water and Waste that represent three standard types of inputs used by most university. These inputs result in outputs of environmental significance, which are captured under the Aspects of Emissions.

Both universities will be described following the priority topics with respective objective, target and performance (for the reporting year and for the following year). Subsequently key initiatives (in reporting years and planned for the following year) will be reported.

5.1.1.1 Energy Aspect

One of the main aspects to be considered is the amount of energy that both universities consume. This can be considered one of the most influential indicators for sustainability, the environmental footprint of the university is shaped in part by its choice of energy sources. Changes in the balance of these choice of energy sources can indicate the universities effort to minimize its environmental impacts.

The consumption of fossil fuel is the major source of greenhouse gas emission, therefore replacing fossil fuel with renewable energy is essential for prevent climate change. The use of renewable energy also reduces the future dependency

on non-renewable source, and its exposure to potential volatility in prices and supply.

For this KPI have been considered the following topic group:

Direct Energy: Form of Energy that can appear in either primary (e.g., natural gas for heating) or intermediate (e.g., electricity for lighting) forms. It can be purchased, extracted (e.g., coal, natural gas, oil), harvested (e.g., biomass energy) or collected (e.g., solar, wind).

Indirect Energy: Energy consumed to supply energy for the University's intermediate needs (e.g., electricity or heating and cooling). One common example is the fuel consumed in order to generate electricity to be used inside the university.

Renewable Energy: Energy that comes from natural processes that are naturally replenished constantly. This includes electricity generated from solar, wind, ocean, hydropower, biomass, geothermal resources, bio fuels, and hydrogen derived from renewable resources.

5.1.1.2 Water Aspect

Clean water is elemental and essential for life. And meeting increasing global water demand with a diminishing supply is one of the world's most pressing issues.

The total volume withdrawn provides an indication of the universities' relative size and importance as a user of water.

5.1.1.3 Solid waste and Recycling Aspect

Data on the total waste generation by type and disposal method can indicate the level of progress the university has made towards waste reduction efforts. It can

also indicate the potential improvement in process efficiency and productivity. Both the production of materials and product and the processing of waste have negative impact on environment. In addition, these processes involve energy usage and cost.

The reduction of waste contributes directly to lower cost of materials, processing and disposal. Most waste minimization strategies emphasize prioritizing options for recovery, reuse, or recycling over other disposal options.

5.1.1.4 Carbon emission Aspect

Greenhouse gas emission (GHG) are the main cause of climate change. All human activities somehow involve emissions, either directly or indirectly.

The six main greenhouse gas emissions are:

- Carbon dioxide (CO_2);
- Methane (CH_4);
- Nitrous oxide (N_2O);
- Hydro fluorocarbons (HFCs- a group of several compounds);
- Per fluorocarbons (PFC- a group of several compounds);
- Sulphur hexafluoride (SF_6) .

For this KPI have been considered the following topic group:

Direct Emission: Direct GHG emissions are emissions from sources that are owned or controlled by the reporting entity

Indirect Emission: Indirect GHG emissions are emissions that are a consequence of the activities of the reporting entity, but occur at sources owned or controlled by another entity.

5.2 Delft University of Technology

Figure 17: Delft University of Technology Campus Area.

Delft University of Technology, also known as TU Delft, is the largest and oldest Dutch public technical university, located in Delft, Netherlands. With eight faculties and numerous research institutes it hosts over 18.781 students (undergraduate and postgraduate), and more than 2.579 people in the support and management staff.

TU Delft's mission is to make a significant contribution towards a sustainable society for the twenty-first century by conducting groundbreaking scientific and technological research which is acknowledged as world-class, by training scientists and engineers with a genuine commitment to society and by helping to translate knowledge into technological innovations and activity with both economic and social value.[43]

[43] www.tudelft.nl

Delft University of Technology – 2013	
Student population	18.781
Academic staff	2.579
Finance (M€)	345.8 (equity capital) 373.6 (government funding) 41.7 (tuition and examination fees) 143.2 (third parties funding) TOT= 904.3
Area	550.000 mq (2012)

5.2.1 Energy

The main project developed by TU Delft to make clear that the energy consumption and production is taken seriously is the TU Delft Energy Monitor.

The Energy Monitor, a joint project of the Delft Energy Initiative and the department of Facility Management & Real Estate, aims to involve members of staff and students in turning the university campus into a fully sustainable environment.

The Energy Monitor shows how much energy is used per building/faculty and for the entire university the monitor shows how much electricity, gas and heat is used and how much CO2 is released. Each graph is thoroughly explained. The website also lists the university's projects aimed at saving energy and switching to renewable energy.[44]

5.2.1.1 Objective and Target

The Dutch government has set target for 2020 as 14% of renewable energy. This keeps the Netherlands in line with the EU renewable energy target for 2020.

[44] Energy Monitor - http://www.energymonitor.tudelft.nl/

According to FMRE & DEI (2014) and also to the choice of the Dutch government TU Delft has set the following set:

- 40% energy reduction of Primary Energy Consumption 2020 (baseline 2005);
- 25% on campus Renewable Production by 2020;
    - 20% renewable heat production;
    - 5% renewable electricity production.
- energy neutral by 2035.

5.2.1.2 Key Initiative

Realization of the Long-term Agreement on Energy

TU Delft has signed the Long-Term Agreement on Energy Efficiency (MJA3), which stipulates that the University must have improved energy efficiency by 30% by 2020, compared to 2005 levels.
The TU Delft Energy Efficiency Plan outlines measures that must be achieved by the end of 2016 in order to achieve a 10-12% improvement in energy efficiency, compared to 2012. The most important project involves the replacement of the gas engines in the TU Delft CHP plant, resulting in a significant increase in the University's own electricity production and the use of residual heat. The new engines are operational since late 2012 and the effects should become visible in the course of 2013. In addition, measures to improve insulation are being taken in a range of different buildings, energy-efficient lighting installed and building control systems improved in order to achieve savings on the use of electricity, heating and cooling. These measures are indicated on this website for each faculty/building.[45]

[45] Energy Monitor - http://www.energymonitor.tudelft.nl/

Develop a geothermal source (doublet) in the campus for heating a substantial part of TU Delft building

At the moment, TU Delft is developing a geothermal source (doublet) at its campus for heating a substantial part of our TU Delft buildings. In 2007, students initiated the "Delft Aardwarmte Project" (DAP, Delft Geothermal Project), which was a major step to increase the Dutch awareness of the potential of geothermal energy as a sustainable heating source in the Netherlands. The Dutch subsoil is well explored with (test) drillings for natural gas and oil, giving insight into the geothermal potential as well. The total heating demand for the built environment and the large greenhouse sector can in principal be covered for many decennia via geothermal energy – without (hardly) any CO2 emissions.

The greenhouse sector can relatively easy switch to geothermal heating, which makes the Netherlands an almost ideal playground to develop this transition – both from the supply and the demand side. This potential forefront position of the Netherlands attracts international attention.

The TU Delft possesses all expertise (subsoil and above ground technologies) to stimulate this development, and to educate the engineers who have to bring the opportunities into practice. It is therefore a logical step to develop a geothermal doublet on the own campus, to reduce the carbon footprint of the university and at the same time use it for research towards technological improvements that further reduce costs and risks. This project is carried out with commercial partners (EBN, Hydreco, WEP, Acquit business development B.V., DWA and Deerns). It focuses on the study of well behaviour over time, the application of new –cheaper- drilling techniques and the transformation of campus buildings –that are currently connected to a classical high temperature heating network- to a lower heating supply temperature.[46]

[46] Energy Monitor - http://www.energymonitor.tudelft.nl/

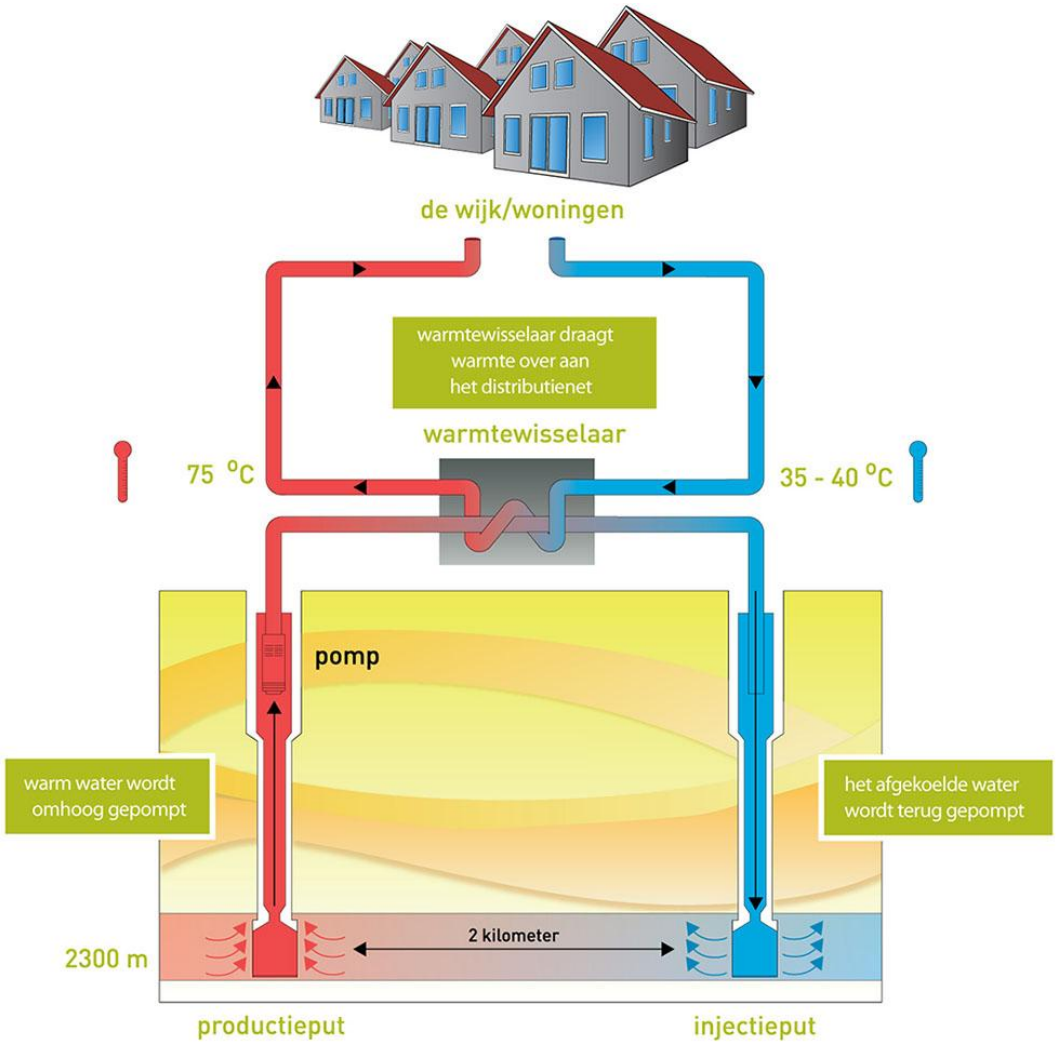


Figure 18: Develop a geothermal source (doublet) in the campus for heating a substantial part of TU Delft building.

Smart Thermal Grids

In the next 15-20 years, the TU Delft campus will be completely renovated, with a focus on sustainable energy supplies. The future climate control system will involve a significant expansion in the use of underground heat and cold storage, as well as the use of geothermal heat, and maybe even the use of residual heat from the nuclear research reactor. In addition, there will also be a complex network of different thermal sources at a range of temperature levels, heat/cold buffers, etc. This development is characteristic of the transition to sustainable heat and cold systems and calls for a radical new approach to control systems. Such a system is being built in alliance with the companies Imtech, Deerns, Van Beek and Priva and research institute Deltares and should be operational in part of the campus by

2014. The smart thermal grid project has been awarded national test bed status as part of the Intelligent Networks Innovation Programme coordinated by AgentschapNL, which will also be co-funding the project.[47]

Smart Street lighting

The TU Delft student Chintan Shah has developed a system for smart street lighting that can reduce the energy consumption of street lighting by 80%. On campus, close to the library, a test site has been established for the system and, depending on the findings, this system will be introduced more widely across the campus. Chintan Shah has started a business, called TVIlight, to manufacture and market the system and even drew the attention of CNN.[48]

Figure 19: Smart Street lighting.

The Green Village project

Initiated by and under responsibility of professor Ad van Wijk (TUD chair "Future Energy Systems"), founder and CEO of Econcern and Dutch businessman of the year in 2007, a part of the TU Delft campus will be transformed by the end of 2014 into the "Green Village".

In "Future Labs", companies, scientists and students will work on paradigm changing themes, "LED revolution", "AC-DC" and "the Car as Power Plant", that will have major impact on our energy future. With a restaurant, an event centre

[47] Energy Monitor - http://www.energymonitor.tudelft.nl/
[48] Energy Monitor - http://www.energymonitor.tudelft.nl/

with major events, shows and conferences throughout the year, and a "green store", an attractive, interactive environment for workers and visitors is created.

The Green Village will obey to the latest insights for sustainable design, for energy supply, water treatment, waste handling, building construction, and underlying financial and legal structures. It shall grow in the coming years to an "autarkic" system – energy, water is harvested from the own environment, and waste (water) discharge does not need further central processing.

New products, systems and services are implemented here when they emerge, for testing, research and further development and to tell the story to visitors. Already, some 100 companies from medium and small enterprises to internationals are involved in the developments, as are all faculties of the TU Delft.[49]

Figure 20: The Green Village project

5.2.1.3 Result

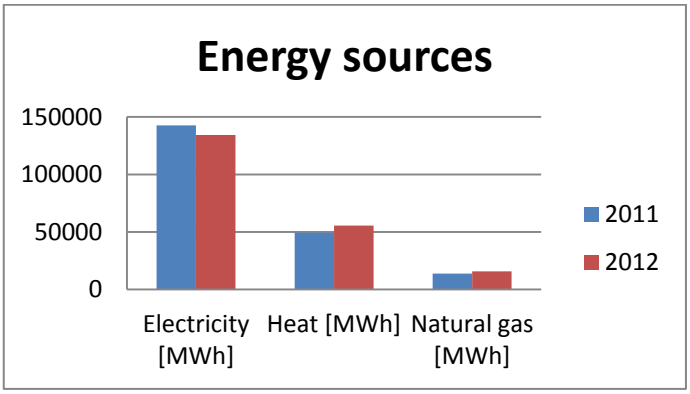
The data that is being used for calculation are derived from the Energy Monitor of TU Delft.

[49] Energy Monitor - http://www.energymonitor.tudelft.nl/

Energy	2011	2012
Electricity [MWh]	142717	134358
Heat [MWh]	49417	55474
Natural gas [MWh]	13799	15757
Tot [MWh]	**205933**	**205589**

The table shows that in 2012 TU Delft has consumed 205589 MWh of Primary Energy, compared to 2011 TU Delft has consumed about 6% less electricity, about 12% more heat and about 14% more natural gas.

It should be considered that the university's energy consumption varies notably in relation to seasonal cycles or weather events.



The graph shows the trend of consumption, is possible to notice that the electricity consumption is much greater than the heat consumption and natural gas consumption. This depends of the fact that some laboratories or IT-departments (Datacentres) for instance can be (very) high in the consumption of electricity.

5.2.2 Water

5.2.2.1 Objective and Target

Target has not been defined. The overall objective is to reduce consumption through voluntary efforts and installation of more efficient technology.

5.2.2.2 Key Initiative

The Water Management department of TU Delft conducts important research on this topic. The Water Management department consists of two sections: Sanitary Engineering and Water Resources.

The Sanitary Engineering section conducts research on the treatment and transport of Drinkwater, waste water, industrial water and related research topics. Particular attention is given to the extraction of materials and energy from the water cycle.

On the other hand, the Water Resources section is focused on the large water cycle. Research topics include water shortages and drought, rainfall, flooding and the behaviour of water in the atmosphere, and on and under the earth's surface. Insights on these research topics ensure that scientists can provide forecasts to predict the response to changes such as climate change or deforestation. How can we optimally regulate water for efficient use and to limit damage.

Through these research topics, even if they are not directly connected to the campus, it's possible to find innovative solutions for water suitable for the universities as well.

Prêt a loger house: Water collection

One of the projects developed within the Green Village[50] is the Prêt a loger, an home with a skin: an extra layer put over the house, which improves both the spatial and the climate performance of the existing house, without touching the quality of a home. The water characteristic of the Skin which is that the gutters are connected with a storage tank of 1,700 litres and the water is used to flush the toilets and water the plants, saving 29,500 litres water every year a reduction of almost 20%. The potable water is a scarce and precious natural resource and this project shows a way to improve one of the most important environmental issues.

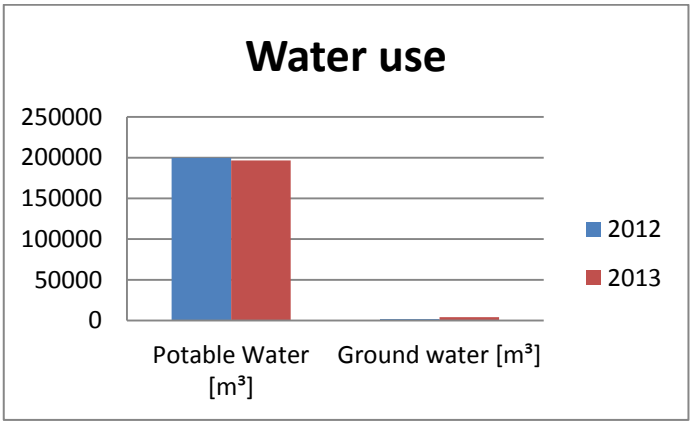
[50] Prêt a loger is developed by students and after the Solar Decathlon the house was rebuilt on the Green Village

5.2.2.3 Result

The data that is being used for calculation are derived from the Energy Monitor of TU Delft.

Water use	2012	2013
Potable Water [m³]	199822	196621
Ground water [m³]	1651	4115
Tot [m³]	**201473**	**200736**

The table shows that in 2013 TU Delft has consumed 200736 m³ of Water, compared to 2012 TU Delft has consumed about 1% less water.



At this moment the only water used is potable water purchased cover the 98% and groundwater extracted cover the 2%. Moreover, waste water or storm water produced at TU Delft is not available for reuse.

5.2.3 Waste and Recycling

TU Delft produces quite a volume of industrial waste and hazardous waste. Besides such industrial waste as waste paper, cardboard and wood, this also includes hazardous waste. Hazardous waste substances are listed in the European List of Waste Eural. Industrial waste and hazardous waste is centrally collected and then professionally removed to a final processor.

At the present there is no information available on plastic waste all of it ends up in non-separated waste and furthermore one negative aspect is the lack of bins for separate collection within the majority of TU Delft's building (only waste paper is collected in the blue bins), with a consequent lack of a process for the management of waste.

5.2.3.1 Objective and Target

The Dutch government launched an ambitious plan for a transition towards a circular economy, which means that in the end all waste should be recycled. The plan aims at 50% reduction of the general (non-separate) waste incinerated between 2012 and 2022, which translates to 5% reduction per year. Therefore the Government's annual 5% reduction is translated into an annual 3% reduction target for TU Delft, assuming the other 2% reduction is achieved by improvements in waste processing.[51]

Moreover, the target of TU Delft is also to try to produce as little waste as possible, and try to separate waste as much as possible

[51] TU Delft Roadmap towards a sustainable campus 2014

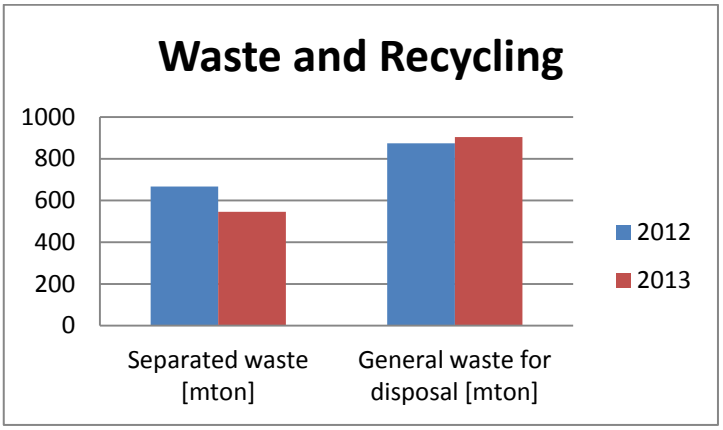
5.2.3.2 Result

The data that is being used for calculation are derived from the Roadmap towards a sustainable campus.

Waste		2012	2013	Difference
Separated waste [Mton]	Wood	73,9	73	-1,2%
	Paper/cardboard	413,6	345,4	-16,5%
	Plastic	0	0	0,0%
	Metal	167,9	113,8	-32,2%
	Organic	0,1	0,1	0,0%
	Hazardous waste	82,9	96,7	16,6%
	Glass	11,6	13,9	19,8%
	E-waste	0,001	0,001	0,0%
	Total separated waste	667	546	-18,1%
General waste for disposal [Mton]	Non-separated waste	874,5	904,4	3,4%
TOTAL WASTE [Mton]		1541,5	1450,5	-5,9%

The table shows a bad score regards hazardous waste and non-separate waste, because the volume were higher than those in 2012. The cause of this increased is not explained, but it should be monitored to better manage the process.

The end result, however, shows a decrease of about 6% over the previous year clearly to attribute to the decrease of metal waste and paper/cardboard.



The graphic shows that in general the level of separate waste and general waste is not so much different, but the general waste is greater than separate waste.
Compared to 2012 TU Delft has produced more general waste and less separate waste.

5.2.4 CO_2 Emission

Carbon dioxide, released when burning fossil fuel, is one of the so-called greenhouse gasses that cause global warming. Worldwide CO2 emission has increased by 2.5 percent annually since the year 2000 and will most likely rise even further during the coming decades. To stabilize global CO2 emission at a level that prevents even more interference with the world's climate system, a reduction of over 50 percent is agreed on. This can be achieved by introducing three main measures: improvements in energy efficiency and energy production, the use of renewable energy sources and the clean use of fossil fuels by capturing and storing CO2. Although energy efficiency and the use of renewable energy are widely promoted, it is becoming clear that these measures alone cannot yet achieve the required emission reductions. CO2 capture and storage (CCS), therefore, is also necessary. That is why researchers at TU Delft are studying the

possibilities of underground CO2 storage in coal beds and nearly depleted gas reservoirs in the Netherlands, as a temporary solution. [52]

5.2.4.1 Objective and Target

The Dutch Government has called for such a greenhouse gas emission reduction target for 2030.More specifically; it has proposed a conditional, European greenhouse gas emission reduction target of 40% below 1990 levels for 2030.[53]

According to FMRE& DEI, 2014, TU Delft set a target to reduce CO_2 emissions from energy consumption by 50% by 2020 and ultimately they want to be CO_2 neutral.

5.2.4.2 Key Initiative

In order to stabilize the world's atmospheric CO2 concentration, serious reductions in carbon dioxide emissions are a necessity. TU Delft researchers are looking into the possibilities of useful underground CO2 storage.

At present, fourteen TU Delft researchers are involved in the Underground CCS monitoring project. It is part of CATO, a five-year national research program on CO2 capture, transport and storage in the Netherlands, initiated by the Dutch government. Parties involved include the University of Utrecht, TNO and Shell. The aim of CATO is to identify whether, how and under which conditions CCS can contribute to a sustainable energy system in the Netherlands from an economical, technical, social and ecological point of view.

[52] TU Delft website - http://www.tudelft.nl/
[53] http://www.pbl.nl/en/publications/2012/greenhouse-gas-emission-reduction-targets-for-2030

5.2.4.3 Result

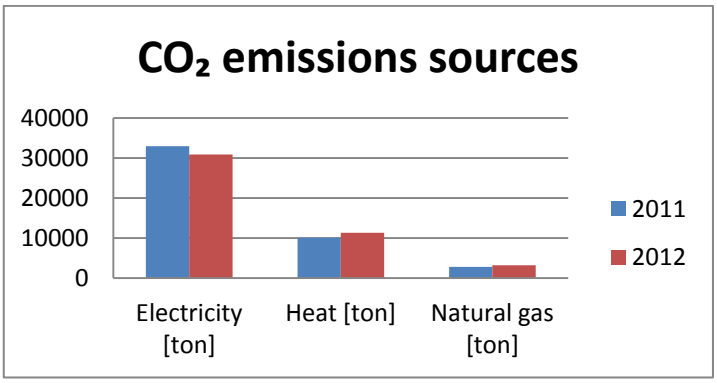
The data that is being used for calculation are derived from the Energy Monitor of TU Delft.

CO_2 emissions source	**2011**	**2012**
Electricity [ton]	32957	30896
Heat [ton]	10087	11323
Natural gas [ton]	2817	3216
Tot [ton]	**45861**	**45435**

The table shows that the CO_2 emission in 2012 respect the previous year:

- from electricity has decreased by about 7%;
- from heat has increased by about 12%;
- from natural gas has increased by about 14%.

Due to the fact that electricity is the most contributors (as the following graphic shows) for emission in total the level has decreased by 1%.



5.3 University of Bologna

Figure 21: University of Bologna Campus Area.

The University of Bologna also known as UNIBO is a university in Bologna, Italy, founded in 1088. As of 2013 the University's crest carries the motto Alma mater studiorum and the date A.D. 1088.

The University has about 86.000 students in its 23 schools. It has branch centres in Bologna, Ravenna, Forlì, Cesena and Rimini. It is recognised as the oldest university in continuous operation, considering that it was the first to use the term universitas for the corporations of students and masters which came to define the institution.

The University of Bologna has among its natural purposes the transfer and valorisation of knowledge, and serves as a promoter of innovation, it is aware of the proper role within the dynamics of local, city and regional.

The two dimensions of sustainability – environmental and social – embrace the idea of cherishing the land, so that natural resources are protected and replenished, and the ability of the people involved to act in an effective concerted manner, facilitated by coordination among the various institutional echelons.

Bologna University's approach to this complex and far-reaching subject is both a project and a plan of action, targeting environmental sustainability from a concrete and pragmatic angle.

University of Bologna (5 Campus) – 2013	
Student population	86.014
Academic staff	5.942
Finance (M€)	631.5 (equity capital)
Area (5 Campus)	934.000 mq

The information below for Energy, Water and Waste comes from The Environmental Sustainability Plan that outlines the University's mission, strategy and Objectives in terms of environmental sustainability.

5.3.1 Energy

5.3.1.1 Objective and Target

Target has not been defined. The main objective is the containment of consumption, both as a consequence of architectural and plants energy efficiency improvement, and as a consequence of a correct use of plants and electrical devices.

The overall objective is:

- Improve the knowledge;
- Manage and control buildings;
- Improve architectural efficiency of buildings;
- Improve plant efficiency of building.

5.3.1.2 Key Initiative

Platform “On Energy” to monitoring power consumption and remote management of plants

Realization of a platform web based for consumption monitoring and remote management of plants. The platform will be installed on the University of Bologna's server, it provides a system of multiuser able to answer to different requirements from person involved in processes of maintenance or management of energy.

The added value comes from being able to have a centralized web platform that allows energy managers, maintenance technicians, to measure the benefits introduced by the redevelopment. It also permits to define new models for the management of the buildings, returning benchmarking indicators is both part of the evaluation of the performance of buildings and in the energy field.

Certificate LEED EBOM

LEED, or Leadership in Energy & Environmental Design, is a green building certification program that recognizes best-in-class building strategies and practices.

University of Bologna wants to obtain LEED certification of buildings in order to achieve the improvement and maintenance, maximizing operational efficiency and minimizing the environmental impact and costs. The objectives of the LEED certification process are:

- saving energy and water and resulting in lower environmental impact and economic;
- awareness building sustainability of the community of the University of Bologna;
- improved health of the building;
- lower maintenance costs.

Installation of Green Roof

The intervention consists in the positioning of covers totally or partially vegetative coverage plans on horizontal buildings that currently operate bituminous surface. The realization of the green roof includes the installation of a package consisting of by the following layers:

- membrane (or mantle) waterproof anti-root;
- separation layer and protection of the waterproof covering;
- layer of drainage and water storage;
- fabric filter;
- growing medium, on which to place the plant material.

The benefits from the installation of green roofs are found in different areas:

- thermal insulation;
- sound insulation;
- bioclimatic improvement;
- high water retention;
- retention of dust in the vegetation and reduction of the phenomenon heat island;
- reduction of energy consumption as a result of a better insulation.

Figure 22: Installation of Green Roof - University of Bologna Via Umberto Terracini 28.

Prototype of sustainable shell for office

The project aims to build a prototype shell for offices with the requirement of almost total energy self-sufficiency. The prototype provides the opportunity to study a first model of behaviour of the building in terms of energy. The parameters deductible will then be adjusted also to existing realities. The benefits of the measure are:

- savings in energy consumption;
- improvement in the evaluation of energy consumption;
- enhancement and use of renewable resources;
- savings in energy expenditure;
- promotion of recycling / reuse.

Disposal of oil-fired central heating and connection to the district heating network of the city

The energy used for district heating is produced for the most part in cogeneration plants which, thanks to the latest technology, produce combined heat and power, with the minimum level the maximum rate of pollution and energy efficiency. This technology, in the face of significant investments in infrastructure, offers a service convenient, simple and safe thanks to the use of hot water, not being a fuel, allows to replace the boiler with a heat exchanger heat which determines the absence of the flame and greater safety for the building. Thermal power stations in the district heating has several advantages and benefits, among which the most significant are:

- reduction of atmospheric pollution and fuel;
- reduction of maintenance costs;
- savings in energy consumption;
- improvement in the evaluation of energy consumption;
- enhancement and use of renewable resources;
- rationalization of natural resources available.

Photovoltaic installation

Production of electricity by renewable energy sources. The energy produced by the plants will be allocated to the operation of the heating / cooling and energy requirements.

The production of electrical energy by photovoltaic technology have several advantages, the most significant are:

- use of renewable resources;
- saving of fossil fuels;
- useful life greater than 25 years;
- containment of maintenance costs;
- Reduction of CO2 emissions.

The benefits derived from the installation of photovoltaic systems are therefore:

- savings in energy consumption;
- development and use of renewable resources;
- savings in energy expenditure;
- rationalization of the available natural resources.

Location	N° of panel	Rated output [kWp]	Area [mq]
Centro di ricerca per le specie avicole	320 (Crystalline silicon, 250 Wp)	**80**	**430**
Blocco aule e laboratori per il corso di laurea in Scienze ambientali	50 (Policrystalline silicon, 250 Wp)	**12,5**	**80**
Tecnopolo, laboratorio di ricerca	42 (Policrystalline silicon, 235 Wp)	**9,87**	**140**
TOT	**412**	**102.37**	**650**

Greenhouses self-sufficient

Analysis and modelling of prototype greenhouse agri-food use energy self-sufficient.

The project, provide the definition of a prototype architectural and technological greenhouses energy self-sufficient, involves the removal food production costs by the elimination of energy costs and rationalization of environmental and renewable resources, as well as the exploitation of food resources. The benefits of this intervention are:

- definition of an optimization model of agricultural production /energy environmental parameters;
- monitoring the operation of facilities;
- testing of innovative solutions by remote control (e.g. apps for Smartphone or tablet for irrigation and control systems).

Replacing lighting system

Savings in energy consumption and reduction of maintenance costs, by replacing a part of the interior lighting in some university spaces.

The added value comes from the replacement of obsolete technological elements and high energy consumption with innovative systems such as DALI and LEDs.

The introduction of the DALI allows to:

- efficient visual comfort and lighting spectacular;
- ease of use, obtained from a coherent integration of software and hardware;
- easy programming of complex lighting situations.

The introduction of LED technology:

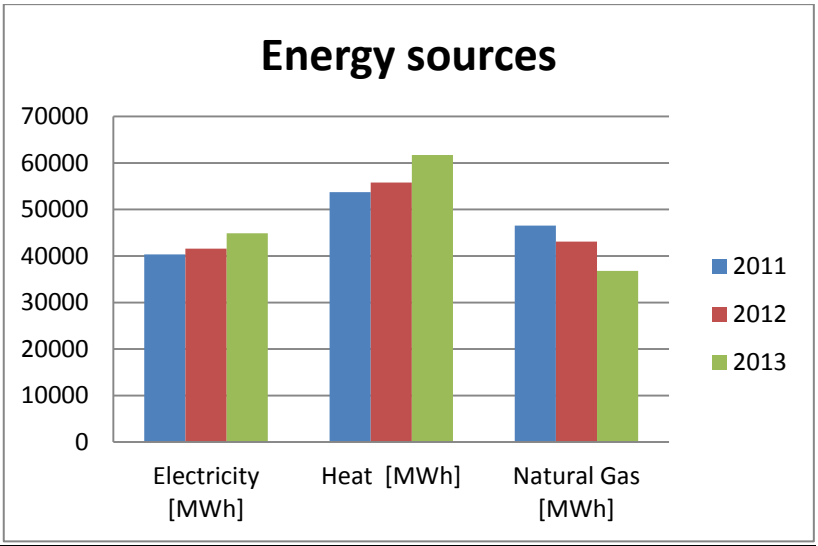
- Increased luminous efficiency;
- Absence of toxic substances;

- Total absence of light pollution;
- No emission of ultraviolet rays.

5.3.1.3 Result

Energy	2011	2012	2013
Electricity [MWh]	40342,72	41569,98	44877,31
Heat [MWh]	53744,32	55792,9	61705,12
Natural Gas [MWh]	46523,25	43106,13	36812,43
Tot [MWh]	**94087,05**	**97362,88**	**106582,4**

The table shows that in 2013 UNIBO has consumed about 106583 MWh of Primary Energy, compared to 2012 UNIBO has consumed about 8% more electricity, about 1% more heat and about 17% more natural gas.
The increase in consumption is mainly due to the opening of new universities. It should be considered that the university's energy consumption varies notably in relation to seasonal cycles or weather events as well.



The graph shows the trend of consumption, is possible to notice that the heat consumption is much greater than the electricity consumption and natural gas consumption.

5.3.2 Water

5.3.2.1 Objective and Target

Target has not been defined. The overall objective is to reduce consumption through voluntary efforts and installation of more efficient technology.

5.3.2.2 Key Initiative

Water flow reducer

Reduction of water consumption and valorisation of water by installing systems of reduction / adjustment of the water pressure in output from the pipes.

The adoption of mechanical systems for the regulation of the flow of water such as to decrease the output pressure reduces the volume of water consumed bringing benefits both in terms of consumption that ethically:

- dissemination of the culture of environmental sustainability;
- rationalization of available natural resources;
- savings in water consumption;
- savings in spending for water.

Installation of distributor of filter water called ‘House of Water’

The project involves the installation of Houses of water in university spaces open. The house has a water dispenser for dispensing filtered water still and sparkling chilled. Under the contract, the delivery water takes place through reading identity badge remaining still accessible to the entire university community (staff and students). The work is accompanied by a contract for cleaning and maintenance installation.

The introduction of Houses of water bring considerable advantages both from a point of environmental and energy saving. These dispensers enabling fact a reduction in the use of bottled water, have the following consequences:

- lower energy consumption due to distributors refrigerated;
- lower emissions from transport;
- less waste production resulting from the disposal of bottles plastic.

Specifically, a recent analysis of comparative LCA water supplied by house and bottled water quantifies the benefits as follows:

- Energy saving: 20% energy consumption compared to water in bottle;
- savings in CO2 emissions: -75% kgCO2eq. than bottled water;
- Waste reduction: -0,019kg PET per liter dispensed.

They also help to raise awareness, promote and enhance the rationalization of natural water resources available and to reduce waste.

Figure 23: Example of "House of Water".

5.3.3 Waste and Recycling

5.3.3.1 Objective and Target

Target has not been defined. The overall objective is:

- Improve the waste reduction and enhancement of natural resources;

- Green enhancement;
- Social sustainability;
- User awareness in the field of university environmental sustainability.

5.3.3.2 Key Initiative

Extension of separate waste and recovery of other materials (such as compost)

Promotion of sustainable standards of conduct and the involvement of all users university to the issue of waste separation. In addition, the benefits of waste separation, such as:

- Reducing the volume of waste sent for disposal;
- Recovery of materials to produce new ones or to turn them into a source of energy;
- Improvement of the environment.

IWEEE system

Another significant action concerns the management of electrical and electronic equipment waste. The University of Bologna has implemented a centralized management system for this kind of waste, especially for the management of the Informatics Electric and Electronic Equipment Waste (IWEEE), also allowing for recovery of this waste. This approach has seen the design of a center for the recovery and preparation for re-use as service for the University of Bologna. Through the involvement of student associations, a trash ware activity has permitted the recovery and the preparation for re-use of IWEEE. [54]

Compost Plant

Another action aimed at closing a loop is the realization of a compost plant at the University Botanic Garden in Bologna. The application of home composting in the Botanical Garden could be a good answer both for the management of residual green waste deriving from cuttings and pruning of all gardens present inside the University and also for a simple fertilizers supply. From the economic point of

[54] Bonoli A., Cappellaro F., (2013) Initiatives to start with implementing sustainability process into University of Bologna, CUCSTorino, 2013.

view, by internal green waste composting, it is possible to obtain soil fertilizers without additional costs, and reducing costs for waste disposal. The Botanical Garden could easily use the amount of compost produced for the fertilization of soils and plants as a service for all structures of the University of Bologna. [55]

5.3.3.3 Result

Several actions connected to waste responsibility can be crucially practiced at different levels of the university structure. As shown in the following table, there is the opportunity to embed the concept of waste responsibility at several levels. [56]

Category	Action	Level	Actors
Waste management	Waste separate collection system	Engineering and Architecture School located in via Terracini and Bologna Bologna Campus	Wide university community
Closing the loop	Compost plant	University Botanic Garden of Bologna Campus	Academic staff, Administrative / operational staff
Policy and behavior change	Informatics Waste of Electric and Electronic Equipment (IWEEE) management	All campuses of Bologna, Forlì, Cesena, Rimini	Academic staff Administrative / operational staff
Closing the loop	Informatics EEE recovery center	Cesena Campus	Students; academic staff;

[55] [56] Francesca Cappellaro, Alessandra Bonoli - Transition as a new participatory approach for achieving the sustainability of the university system

			administrative / operational staff
Closing the loop	Water fountains	Bologna Campus	Wide university community and neighborhood citizens
Policy and behavior change	Laboratory of Sustainability Transitions	Engineering and Architecture School located in via Terracini, Bologna	Students

The University of Bologna, the city of Bologna and Hera SpA launched a project for the disposal of recovered materials within the university the historic center of Bologna.

The Memorandum of Understanding between the three partners provides recovery services:

- Paper;
- Plastic;
- Glass
- Toner;
- Batteries.

Numbers:

- 77, structures of the UNIBO where the recovery service is active;
- 2000, Ecobox "UniboGreen" allocated for plastic and paper recovery;
- 10 tons of paper and cardboard is the average for month;
- 1 tons of plastic packaging is the average for month.

5.3.4 CO_2 Emission

On October 9, 2014, University of Bologna and The Environment Ministry sing a protocol of agreement for the development of mutually beneficial cooperation in enforcement Directive 2003/87/EC (EU ETS) in the exchange of shares of greenhouse gas emissions, in order to support policies to mitigate and adapt to climate change.

The objective of this agreement is mainly:

- Ensure the monitoring of CO_2 emissions;
- Continue and strengthen the transfer of knowledge and methodologies about the procedures for reporting emissions;
- Develop scientific activities for information and education, with the aim to train professionals capable of governing the variable of sustainability with a particular focus on environmental and social responsibility in the financial markets.

5.3.4.1 Objective and Target

The target has not been defined but the overall goal of each project developed in Bologna aim to reduce pollutant emissions into the atmosphere.

6 SWOT ANALYSIS: Strengths, Weaknesses, Opportunities and Threats

In order to provide a better understanding of the current state of sustainability on University of Bologna and Delft University of Technology, and potential strategies to achieve the stated objective, a SWOT Analysis can be undertaken.

SWOT Analysis is used to evaluate the Strengths, Weakness, Opportunities and Threats involved in a project, or any other situation requiring a decision. Consequently, the objective is to apply this method of planning with the intent that concepts described here can be used to strengthen and guide this emerging discipline.

Different factors considered for the SWOT analysis:

- Strengths refer to the internal characteristics which may be deemed favourable for the university.
- Weaknesses refer to the internal characteristics which may be deemed unfavourable for the university.
- Opportunities are external characteristics which the university may use to its advantage.
- Threats are external characteristics which may be potential sources of failure to the university.

Moreover, the SWOT analysis conducted about sustainability for universities can provide prompts to the governors, management teachers and staff involved in the analysis of what is effective and less effective in the university systems and procedures, in preparation for a plan of some form (that could be an audit, assessments, quality checks etc.). In fact a SWOT can be used for any planning or analysis activity which could impact future finance, planning and management decisions. One of the most effective ways to conduct a SWOT analysis for university is not to do it in isolation, but with a team effort. For this reason both in Delft and in Bologna a brainstorming session has been run with coordinators of sustainability.

In order to make a "Sustainable SWOT" was considered the model proposed by People and Planet[57], so it is necessary to evaluate the following matters:

- Environmental Policy
- Environmental Staff
- Auditing & EMS

[57] People and Planet is the largest student network in Britain campaigning to end world poverty, defend human rights and protect the environment.

- Ethical Investment
- Carbon management
- Engagement
- Education
- Energy Sources
- Waste & Recycling
- Carbon Reduction
- Water Reduction

Energy, Waste, Carbon and Water were already discussed in the previous paragraph through ISCN methodology, while the remaining topics are explained in detail below.

6.1 Environmental Sustainability: Policy and Strategy

An environmental policy provides a formal, public and permanent demonstration of intent regarding performance. It is crucial in ensuring there is sustained, strategic improvement in environmental performance, backed up by senior management and with adequate resources.
Policy, targets and reporting are key drivers of performance improvement across the sector; set specific and time-bound targets or performance indicators covering all major aspects of environmental management.

- Publicly Available Policy

  Does the university have a publicly available environmental (or environmental sustainability) policy published within the last 5 years and reported on annually to a senior level of the university?

- Targets and Strategy

  Is the policy accompanied by an action plan/ strategy OR separate policies and accompanying plans which cover the following 8 areas?

    - Construction & Refurbishment

- Emissions & Discharges
- Community involvement
- Biodiversity
- Waste management
- Travel and Transport
- Sustainable procurement
- Water

6.2 Human Resources for Sustainability

It has been repeatedly demonstrated that without the expertise and championing of professional staff dedicated to environmental management, sustainability initiatives in universities are unlikely to be systematic, well-coordinated and resourced, or have significant long-term success.

- Governance
  Is sustainability included within the portfolio of responsibilities of a member of the university senior management team?

6.3 Environmental Auditing & Management Systems

Only by analysing and regularly auditing its different environmental impacts can an institution set targets, assess priorities and monitor performance improvements.

Is the university accredited to an external environmental management system? (ISO14001, EMAS, Ecocampus, Green Dragon, BS8885)

6.4 Ethical Investment

Ethical investment policies are not only necessary to direct decision-making around the investment of ‘extraneous funds’. They inform decisions about all areas of investment conducted by an institution, including but not limited to

pension fund investments, equities investment and an institution's choice of banking providers.

- Found
  Does your university have funds to invest in sustainability?

6.5 Carbon Management

A steep and annual reduction in global carbon emissions is required to avert catastrophic global climate destabilisation.
Institutions should take a holistic approach to carbon management by including the full scope of their emissions in the reduction targets they set themselves. Transport, waste and procurement activities are shown to account for up to 50% of an institution's carbon footprint.

- Carbon Management Plan and targets
  Does the University have a publicly available carbon management plan which meets the Carbon Trust and most current Capital Investment Framework requirements?

6.6 Staff and Student Engagement

Whilst universities are directly responsible for many environmental impacts through their operations, the university community also contributes significantly to its overall environmental impact through its behaviour - for example, consumption of electricity or travel habits.

Universities that play an active role in encouraging and engaging students and staff in sustainable behaviour change will be able to make continual improvements in holistic sustainable development more smoothly, cheaply and quickly.

Engagement can have a wider and more significant impact when behaviour and values experienced by staff, students and visitors to the university begin or embed long-lasting change throughout a person's life.

- Engagement Strategy

  Is the university committed to student and staff engagement for sustainability through the development of a strategy or several strategies that include SMART targets and commit resources to continual improvement in this area?

6.7 Education for Sustainable Development

What is meant by education for sustainable development?

'There is increasing recognition that these three factors [economic, social and environmental] are interconnected, overlapping and interdependent. Drawing on both the 1987definition and its 2005 recalibration, the present guidance defines education for sustainable development as follows: Education for sustainable development is the process of equipping students with the knowledge and understanding, skills and attributes needed to work and live in a way that safeguards environmental, social and economic wellbeing, both in the present and for future generations.'[58]

Education for sustainable development means working with students to encourage them to:

- Consider what the concept of global citizenship means in the context of their own discipline and in their future professional and personal lives.
- Consider what the concept of environmental stewardship means in the context of their own discipline and in their future professional and personal lives.

[58] The United Nations World Summit, 2005

- Think about issues of social justice, ethics and wellbeing, and how these relate to ecological and economic factors.
- Develop a future- facing outlook.
- Learning to think about the consequences of actions, and how systems and societies can be adapted to ensure sustainable futures.

6.8 SWOT Analysis Delft University of Technology

This SWOT analysis is created with contributions of TU Delft campus sustainability coordinators.

6.8.1 Strengths

In order to analyze the strength about sustainability of TU Delft the main questions that have been followed are:

- What does TU Delft do well?
- What unique resource can TU Delft draw on?
- What do others see as TU Delft's strengths?

Not every field considered is directly connected with the issue of sustainability, but it is still important as a means to achieve it.

Target set for Energy and CO_2 emission

About policy and strategy TU Delft has set important target for energy and emissions. Sustainability performance targets are an important part of a university's sustainability strategy although a Strategic Plan does not yet exist for TU Delft this will help to create the foundation. TU Delft has as its ultimate goal to become energy-neutral and completely CO_2 neutral by 2035.

Energy Monitor and Long term agreement

In order to analysing and regularly auditing its different environmental impacts TU Delft has developed an important step through sustainability, The Energy Monitor. Electricity, natural gas and heat usage is shown for each building and for the campus as a whole. With this website TU Delft want to share information on the trajectory the TU Delft is following to improve the sustainability of its energy usage.
Moreover, in a long-term agreement (the MJA3), the Dutch universities, including TU Delft, committed themselves to improving energy efficiency by 2% per year until 2020: by 2020, energy efficiency must have improved by 30% compared to 2005 levels.

Strong embedding of sustainability themes in research

Much of the TU Delft research has an im- or explicit relation to sustainable development. For instance, some 700 scientists work on the energy theme, and the TU Delft has top position in some of these areas. Also, fundamental sciences are often deeply inspired by sustainable development. In Delft, an example is the development of the Qbit computer in our world leading KAVLI Institute. The Qbit computer can dramatically increase computational calculation power, which is a prerequisite to develop new materials from well available material sources for specific functions.

Sustainable Community

The university is committed to student and staff engagement for sustainability through the development of a Sustainability Community, a joint effort from TU Delft's student.
The sustainability Community is an "umbrella" organization that consist of all student led initiatives that are related to sustainability issues within the TU Delft. The community include:

- Climate City Campus, is a Delft Environmental Initiative, which uses the TU Delft Campus, a small city in its own right, as a living lab;

- D-Exto, is the Innovation Engine from the Delft Campus, it travels different event festivals with the flexible D-exto pavilion to give Campus project a platform to test and pilot their project in a real life setting.

- Ecolution, students from various faculties that offer all discipline a platform to meet, share information and try and implement more integrated solutions;

- Energy Club, is led by six ambitious Master's student from TU Delft. It is a student run platform that was born out of a desire to act towards a sustainable energy society and facilitate the personal and professional development of students;

- Passiegroep, is an initiative started in 2011 by Professor Anke van Hal. I is a network that bring students and professional together who share a passion for the existing build environment;

- SHIFT, is the study association of the MSc Industrial Ecology at the Technical University of Delft and Leiden University. It aims to bring IE students closer to the academic and professional fields of sustainability by organizing workshops, excursion and other events with various firms, professionals, associations and networks;

- SMART Campus, sustainability monitoring and research team, aims to realize a coordinated TU Delft community that continuously strives towards a campus environment embodying sustainability in research, education and operations;

- SHS, is a non-profit organization that engages in the redevelopment of vacant building such as offices into student accommodation;

- Student for sustainability, is a foundation, which was set up by TU Delft students 7 years ago. They help community in developing countries all around the world to increase their stability and livelihood.

Education for sustainability

TU Delft offers 16 Bachelor's programmes and over 35 Master's programmes in the fields of science, engineering and design. All Master's programmes are taught in English. The strength relative to sustainability in relation to the field of education is derived from the various Master addressing this issue, including:

- Master of Science Sustainable Energy Technology, in which are taught course as 'Sustainable Hydrogen and Electrical Energy Storage';
- Master of Sustainable Process and Energy;
- Master of Technology of Sustainable development, in which are taught course as 'Technology and Global Development', 'Technics and Future', 'Technology in Sustainable Development', 'Technology Dynamics for Sustainable Innovation', Technology Dynamics and Transition Management', Sustainable Development for Engineers.

These courses therefore reflect the commitment of TU Delft in sustainability, as they allow to train competent people and explores how tomorrow's human societies can endure in the face of global change, ecosystem degradation and resource limitations.

Good position in the World and European University Ranking

TU Delft is ranked among the top universities of technology in the world, TU Delft's excellent research and education standards are backed by outstanding facilities, research institutes and research schools. TU Delft maintains close links with (inter)national industry, a strategic alliance contributing to the relevance of its academic programmes and career prospects for its graduates.

All education programmes encourage creative and independent thinking with a focus on problem solving. The student body is made up of over a 100 nationalities. The university has partnerships with more than thirty leading universities all over the world, enabling students and researchers to increase their international experience through cooperation and exchange.

Provably The Times Higher Education World University Rankings 2014-2015 lists the best global universities considering important performance indicators to provide the most comprehensive and balanced comparisons available, which are trusted by students, academics, university leaders, industry and governments. As the table shows, TU Delft fulfils the 71 place in the World Ranking and the 19 place for the engineering and technology universities top ranking.

	World University Rankings 2014-2015	**Top 100 universities for engineering and technology 2014-2015**
Delft University of Technology	71 (400)	19

Location

The location of the University in Delft is in a picturesque city full of student activities, and within close range within major cities in the Netherlands and the rest of Europe. TU Delft is therefore placed in the heart of Europe, a strategic position within the European context.

Figure 24: Location of Delft in Netherlands.

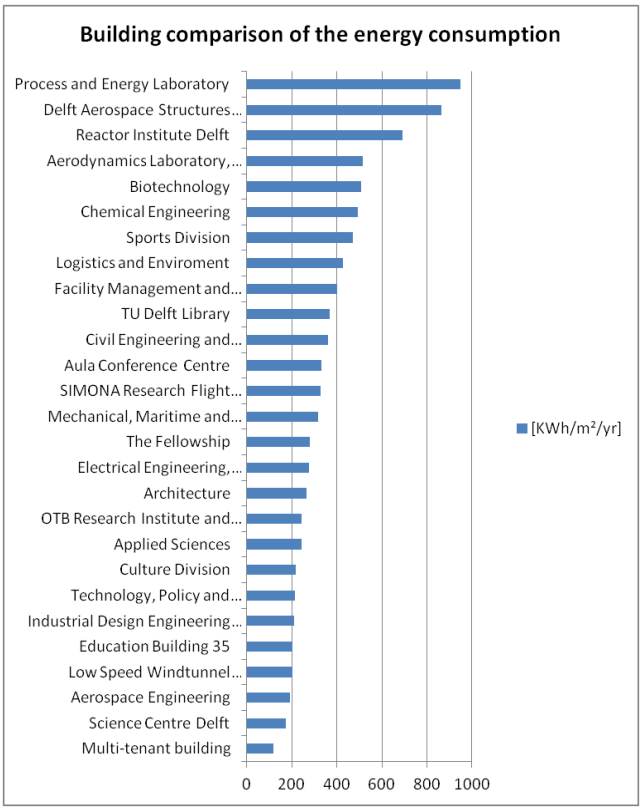
6.8.2 Weaknesses

In order to analyze the weaknesses about sustainability of TU Delft the main questions that have been followed are:

- What could TU Delft improve?
- Where does TU Delft have fewer resources than others?
- What are others likely to see as weaknesses?

Energy consuming laboratory

Developing new knowledge by doing research is a primary goal of the university. This comes with use of laboratories, and a large scale research facilities that sometimes are big energy consumers, for example the Process and Energy Laboratory, Delft Aerospace Structures and Materials and a flight simulator on the campus. Another high-energy consuming laboratory is the Reactor Institute, used by the department of Radiation Science & Technology. The table below show the energy consumption for every department.



Integration of sustainability into existing organization

A strong track towards campus sustainability requires full commitment, cooperation and clear procedures for support departments such as procurement, ICT, and Facility Management and Real Estate. Special attention is required to make "total costs of ownership" leading in investment decisions, that are traditionally based on reserved investment budgets. Sustainable solutions require in general higher upfront investments. A revolving fund can make the difference here, which requires also adequate monitoring of savings (energy, maintenance and so forth).
A coherent university wide approach still needs to be developed.

Sustainability strategy is not complete

Although targets are set for energy use, energy efficiency and CO_2 emissions, no target are set yet for the other sustainability topics such as water and waste.

6.8.3 Opportunities

In order to analyze the opportunities about sustainability of TU Delft the main questions that have been followed are:

- What opportunities are open to TU Delft?
- What trends could TU Delft take advantage of?
- How can TU Delft turn your strengths into opportunities?

Available subsidies to improve campus sustainability

TU Delft successfully applied for (national) funding to install 1MW of solar-PV panels on the campus building in 2015. There is also funding available to replace the regular TL lights by LED. In both cases subsidy counterbalances the extra

investment for this sustainable technology compared to the investment for less sustainable energy technology.

Build a new kind of organization

As mentioned earlier, the TU Delft-wide sustainability strategy has started recently. This gives the opportunity to learn from other universities in how they organize their sustainability strategy.

6.8.4 Threats

In order to analyze the opportunities about sustainability of TU Delft the main question that has been followed is:

- What threats could harm TU Delft?

Long return rate on sustainable investment

University budgets must serve the prime focus of a university: education and research. Reserving money for investing in sustainable solutions with high upfront investments and long payback times, can counteract required financial flexibility for our prime responsibilities.

Creating a structure and making changes takes time

For TU Delft, sustainability targets have been set for the future, and mainly on the energy-related goals. Although these goals are supported by a SMART plan, indicating that net costs in a total costs of ownership approach are close to zero, it requires a new strategy with focus on sustainable development in the complex university organisation with its support departments and faculties, with their own financial and strategic responsibilities. The time required to set all wheels in motion is probably the major threat to achieve our goals.

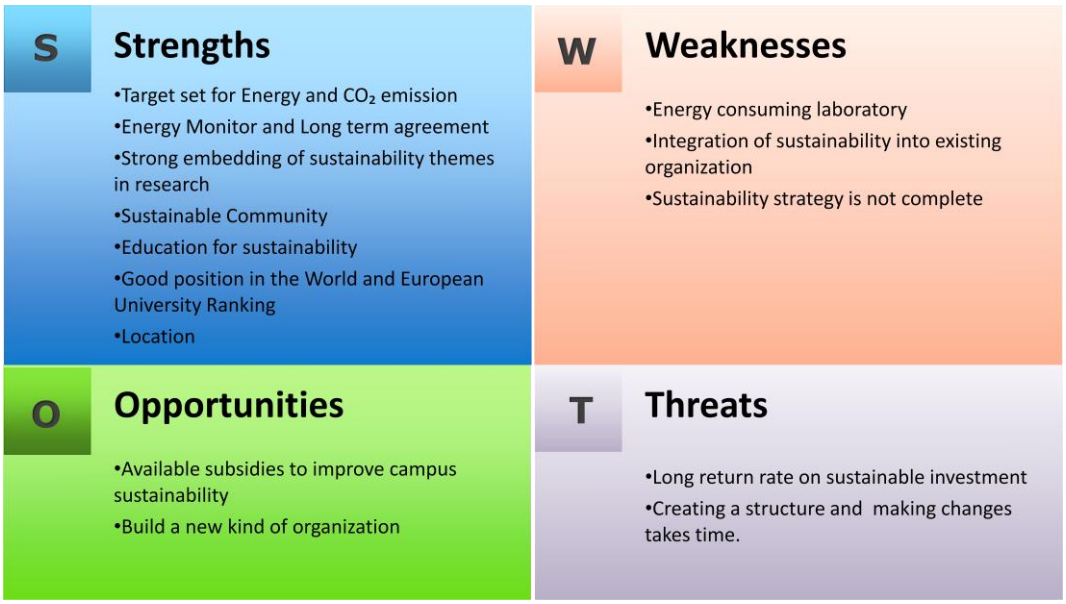


Figure 25: SWOT Analysis TU Delft.

6.9 SWOT Analysis University of Bologna

The SWOT analysis for the University of Bologna was made through a brainstorming with the main coordinators of the sustainability of Multi campus.

6.9.1 Strengths

In order to analyze the strength about sustainability of UNIBO the main questions that have been followed are:

- What does UNIBO do well?
- What unique resource can UNIBO draw on?
- What do others see as UNIBO's strengths?

Not every field considered is directly connected with the issue of sustainability, but it is still important as a means to achieve it.

Environmental Sustainability Plan

The Environmental Sustainability Plan outlines the University's mission, strategy and objectives in terms of environmental sustainability.
The Plan is a strategic document that provides direction on common management issues such as energy-efficiency, water and resource use, waste management and eco-building by the adoption of the appropriate technology. These issues are addressed with a range of actions that include education (and behavioural change) and responses to climate change.

Sustainable Initiatives in Facilities Management- AUTC

The mission of the AUTC Sector is to define strategies in the context of environmental sustainability and facility management, taking care of the relationship between the building and environmental context, working in collaboration with the organs of the University and with the sustainability coordinator of the university. The activities are conducted primarily in measures to:

- Energy saving;
- Promotion of sustainable mobility;
- Realization of eco-compatible architectures;
- Respect for the environment;
- Real estate management, in view of the maintenance over time of the building and the continuous improvement of services and its functions.

Multidisciplinary approach: Alma Low Carbon

The University of Bologna has adopted a Multi campus structure in order to permit the diffusion of educational offering and the activation of a stabile research activity. In accordance with that "Alma Low Carbon" is a multi-disciplinary group at the University of Bologna working in the field of energy, environmental sustainability and the transition towards a "low carbon" society.

Alma Low Carbon is a group of over one hundred professors, researchers and research staff from over twenty university departments: a significant critical assembly, aiming to improve scientific and technological exchanges and relations with socio-economic areas to foster the development of new ideas in research and innovation. This objective is achieved by the cross-fertilisation of the different expertise working together in Alma Low Carbon, tackling challenges in the energy and environmental fields.

The Alma Low Carbon Integrated Research Team coordinates the scientific competencies of the University of Bologna, its thematic structure based on the European Horizon 2020 priorities for Research and Innovation:

- Energy Efficiency
- Competitive Low Carbon Energy
- Waste: a resource to recycle, reuse and recover raw materials
- Water Innovation: boosting its value for Europe
- Growing Low Carbon, resource efficient economy with sustainable supply of raw materials
- Social, environmental and Economics aspects of the energy system

Alma Low Carbon is therefore a qualified interlocutor and key partner for all stakeholders in the sector, for academic, industrial and strategic initiatives: a single point of access for the many energy and environmental competences of the University of Bologna.

Transition approach: Transition Team and Sustainability Transition Laboratory

Transition Team aims to steer the transition process in order to create a living-lab of sustainability. The team involves researchers, professors, administrative staff, technicians, PhD and Master students. Moreover, at the School of Engineering and Architecture is ongoing a Sustainability Transition Laboratory that offers new opportunities and useful feedback to research and teaching, as well as contributing to the creation of a living-lab with the engagement of engineering students.

Achieving a sustainable approach at the School of Engineering and Architecture in Terracini leads to improve by economic and environmental point of view also increasing the involvement and the empowerment of staff and students.
A "living laboratory of sustainability" has been created and it promotes an implementation of best management practices of natural resources as energy and water, waste reduction and recycling.

In this way concrete actions are involving students, researchers and teachers. Furthermore the involvement of the administrative staff is crucial for the success of all these sustainable initiatives, especially for what concerns the operational management of facilities such as offices and laboratories. Finally, the participation and training of students on sustainability issues can allow them to make a direct experience of sustainable practice thus they can increase their skills and develop a correct approach for a sustainable lifestyle.[59]

Strong sign of this approach was also the visit and conference in the winter of 2014 by Rob Hopkins co-founder and leader of the movement of Transition Towns and of the Transition Network.

Figure 26: Transition Team and Sustainability Transition Laboratory.

[59] Francesca Cappellaro, Alessandra Bonoli - Transition as a new participatory approach for achieving the sustainability of the university system

University aligned with Regional, National and International agreements

The University of Bologna subscribed the PAES - Action Plan for Sustainable Energy, a document that defines energy policies of the City of Bologna in order to reach the European target of reducing CO2 emissions by 20% by 2020. This goal will be pursued by actions to reduce energy consumption of the city and increase the production of energy from renewable sources.

The University of Bologna aims to become part of the International Sustainable Campus Network (ISCN) that provides a global forum to support leading colleges, universities, and corporate campuses in the exchange of information, ideas, and best practices for achieving sustainable campus operations and integrating sustainability in research and teaching[60].

6.9.2 Weaknesses

In order to analyze the weaknesses about sustainability of UNIBO the main questions that have been followed are:

- What could UNIBO improve?
- Where does UNIBO have fewer resources than others?
- What are others likely to see as weaknesses?

Not clear organizational coordination for sustainability

Thus far at the University of Bologna each sustainability initiatives often start from the bottom usually from departments, this emphasizes that there is a lack of coordination and a the structure is not clear. Moreover, a sustainability commitment requires integration at all level of the organization which so far is not present.

[60] The International Sustainable Campus Network (ISCN) - http://www.international-sustainable-campus-network.org/

High complexity Multi campus management

Managing a multi campus is difficult because the different faculties and facilities are located in different cities and what may work for an establishment sometimes does not work for others, consequently it is necessary to implement ad hoc solutions for each different places.

Lack of CO2 emissions monitoring system

The university monitors different aspects of sustainability (i.e. Energy, Water, Waste, Mobility) but there is no real system for monitoring emissions of CO2. The lack of a monitoring system on carbon emissions is a significant barrier to the efforts to reduce emissions. This is therefore a consequence of the lack of clear responsibilities for carbon management within the university.

6.9.3 Opportunities

In order to analyze the opportunities about sustainability of UNIBO the main questions that have been followed are:

- What opportunities are open to UNIBO?
- What trends could UNIBO take advantage of?
- How can UNIBO turn your strengths into opportunities?

Establishment of a clear Organizational Structure for Sustainability coordination

The establishment of a clear Organization Sustainability Structure which involves all faculties, departments and the whole university is an important action which promotes the integration of sustainability principles into the existing organizational units. Moreover, the establishment of such organizational structure would support the main strategic mission.

University of Bologna as an example of sustainability for the city

Considering the integration of the university within the city of Bologna, UNIBO could play a role as a model of sustainability for the entire city. What is being implemented within the university can simply be replicated for the city to create not only a more sustainable university but a sustainable city.

6.9.4 Threats

In order to analyze the opportunities about sustainability of UNIBO the main question that has been followed is:

- What threats could harm UNIBO?

Lack of financial incentives from government

Due to the current situation in Italy, in particular because of the crisis, University of Bologna cannot predict how many incentives for government will be issued to become more sustainable.

Improving energy efficiency in historic Buildings is difficult and expensive

Most of the faculties of the University of Bologna are located in the historic centre of the city, where many historic buildings are public property in which there is the crucial issue of energy efficiency and use of renewable sources. The fuels used for heating these buildings are expensive, in addition, there are specific standards to be met to achieve redevelopment consequently the results so far are insufficient.

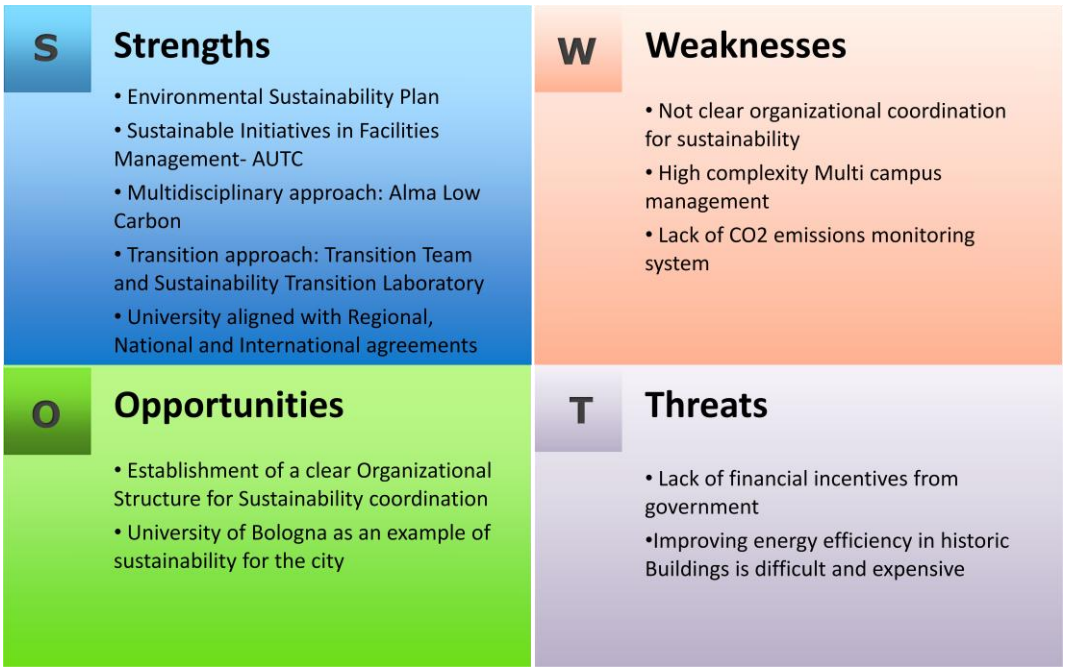


Figure 27: SWOT Analysis UNIBO.

7 How and why should we create a bridge between TU Delft and UNIBO

Partnerships are key to the achievement of sustainability. The University is continually working to extend its partnerships and share learning and practice in sustainability. It is fundamental to the civic aims of the University that it engages with the world beyond the campus walls and with a wide range of community needs and interests. Positive outcomes coming out of research projects and programs implemented with equal support and participation from university. By sharing a common vision research partnerships are proving to be a definite link to better quality of sustainability.

The creation of a bridge between the University of Bologna and the University of Delft aims to join forces to create a new generation of talent. People able to support universities in the exchange of information, ideas, and best practices for achieving sustainable campus operations and integrating sustainability in research and teaching. To inspire, encourage and support both universities to develop and implement their own transformative strategies for establishing green, resource-efficient and low carbon campuses.

7.1 Seven concept for successful collaboration

Both parties shall discuss the problems involved to the satisfaction of each party and enter into specific activity agreements based on the mutually agreed objectives and outcomes of the relationship. The working relationships of partners from diverse backgrounds can become challenging. To simplify the partnership process, it helps to create norms and shared practices to which everyone can refer:

- Authentic partnerships

  A clear presentation of the partnership (written agreement or public statement);

- Capacity building

  Build knowledge, develop skills, and restructure organization so partners are able to devise creative solutions to development challenges and continue to respond to new challenges as they arise;

- Problem solving focus

  Collaborations have a strong focus on solving problems. The partner may not have sufficient capacity or resources to address them, often identifies these problem. Through their discussion, partners often help to develop a clearer definition of the issues

- Mutual benefit

  For collaborations, partners must be mutually beneficial. These benefits do not have to be the same, however all parties must see that their efforts are leading to outcomes which might not otherwise be achieved;

- Resource sharing
  - Exchange of materials in education and research, publications, and academic information;
  - Exchange of the faculty and research scholars;
  - Joint research and meetings for education and research
  - Technical assistance;
  - Student exchanges

- Sustained(sustainable long-term) relationship

  Commitment to long-term goals is often very important. The collaboration should be developed with the intention of finding ways to sustain relationship over time;

- Transparent methods

  All aspect of the collaborative partnership should be discussed in an open and transparent way.

7.2 The sustainable role of e-collaboration

There are various forms of knowledge management that knowledge sharing has been identified as a major focus area for knowledge management because knowledge sharing provides a link between the level of individual knowledge workers, where knowledge resides, and the level of the institution, where knowledge attains its value for the institution . [61]

With the development of new technologies, and particularly e-collaboration and communication technology, groups have evolved to encompass new forms of interaction and collaboration. The World Wide Web enables teams to share knowledge and work remotely on a project. E-collaboration tools such as videoconferencing, group support systems (GSSs), distance education tools (e.g., Blackboard, WebCT), and, more commonly, email have evolved exponentially. These electronic modes of communication support mainly decentralized networks of communication. The new metrics of time and distance modify human interactions and, indeed, turn the classic network of face-to-face relationships into a network of virtual relationships. The modification of the nature of human interactions is the immediate correlate of a faster spread of information and sharing knowledge supported by ICTs.[62]

Electronic collaboration and communication is the purposeful use of networking and collaboration technologies to support teams in the creation of shared understanding toward joint effect. This concept has been developed through many years of research in how people use various collaborative tools in the purpose of sharing knowledge to achieve their tasks and goals.[63]

Several advantages are incorporated into using e-collaboration technologies both in government organizations and private institutions. Saul and Zulu (1994) cautiously mention electronic collaboration technology tools as a means to an end instead of an end in itself. The e-collaboration technology tools and systems are

[61] Ford, D., Knowledge sharing: Seeking to understand intentions and actual sharing. Unpublished doctoral dissertation, Queen's University, Kingston, Canada. 2004.
[62] Routkowski, A., Vogel, R. D., Genuchten, V. M., Bemelmans, M. A. T., & Favier, M., E-collaboration: The reality of virtuality. IEEE transactions on professional communication, 2002.
[63] Fjermestad, J., & Hiltz, R. S. Group support systems: A descriptive evaluation of case and field studies, Journal of Management Information Systems, 2000.

useful in assisting government and private entities in bringing solutions to the problems and thus can be justified according to the advantages and benefits that they result.

Cost reduction as well as the better service quality is among the most obvious reasons that follow up the implementation of e-collaboration systems, benefitting the incorporation using them. The institutional capacity will be effectively improved, not to mention the enhanced decision-making processes and boosted inner efficiency. Another rather important parameter, which will be effectively improved, is the transparency within the institution that will eventually benefit overall performance. Upon the implementation of these tools, taking advantage of advanced technologies, access to information will become much easier throughout the facility. Ushering toward the real time processing of data. The cheaper and more efficient access to the larger amount of information with larger and more advanced computers is good enough reasons to add to the number of pro technology followers.[64]

The ICT sector has transformed the way we live, work, learn and play. From mobile phones and micro-computer chips to the internet, ICT has consistently delivered innovative products and services that are now an integral part of everyday life. ICT has systematically increased productivity and supported economic growth across both developed and developing countries. But what impact do pervasive information and communication technologies have on global warming? Is it a sector that will hinder or help our fight against dangerous climate change?

In 2008 the Climate Group, in collaboration with management consultants, McKinsey, and the Global e-Sustainability Initiative (GeSI), published the seminal report Smart 2020. The report highlighted the potential for Information and Communication Technology (ICT) to lead the transition to a low-carbon economy by saving 15% of global emissions by 2020.[65]

[64] Gichoya, D. Factors affecting the successful implementation of ICT projects in government. The Electronic Journal of e-Government, 2005.

[65] The Climate Group on behalf of the Global eSustainability Initiative (GeSI), SMART 2020: Enabling the low carbon economy in the information age

Advances in information and communications technology have created new opportunities to provide increased flexibility. These technology changes have fundamentally altered the relationship between employees, students, their offices and their work. For example:

- Cloud computing allows workers to access their emails and files from any location, unlike the letters that require a logistics and produce waste;
- Smart phones and cell phones are ubiquitous, and phone calls can be automatically routed seamlessly to multiple devices regardless of location;
- Multimedia teleconferencing and video conferencing allow direct interaction without the time, money and emissions spent on travelling to a common location;
- Document-sharing software allows select groups to work simultaneously or through a shared arrangement on the same document; and
- E-training has increasingly shifted learning online at far lower costs and with reduced travel time.

7.3 Transition Management Approach

Now the question that must be asked is: What kind of approach should be used? In order to reach a successful collaboration between UNIBO and TU Delft is necessary to address it towards a transition approach. Consequently the Transition Management can offer to policy makers who position sustainability at the core of the development. The concepts of transition and transition management offer a fruitful context for cooperation and debate among scientists within the university. Transition management and transition approach in general provide an integrative approach to analyze and formulate an unconventional pathway towards sustainability. Transitions' approach is not to achieve fixed goals, but to gradually work towards common ambitions through innovation, integration, and co-evolution.

Therefore it is given a definition of Transition Management according to the manual of DRIFT[66] "Transition Management in the urban context" in which Five European cities pioneered with transition management, a governance approach Aimed at creating space for new paradigms and practices, to address climate change at the local level.

Transition management is based on the empirical and theoretical insights of transition studies, and offers ways to influence the direction and pace of societal change dynamics towards sustainability.

The approach has been used to stimulate sustainability transitions in localities (e.g. regions, cities and neighbourhoods), and to initiate transformations in socio-technical systems, such as energy, water, and mobility.

The transition management approach proposes six principles for influencing transitions:

1. Get an insight into the system: The complexity of the challenges has to be fully acknowledged. It is essential to understand the dynamics and interlinkages of multiple domains, actors, and scales. This can be done by thoroughly examining the existing situation, as well as by questioning assumptions, problem perceptions, and dominant solutions.

2. Aim for system innovation in small but radical steps: Recognize the difference between system optimisation and system innovation. The latter requires taking small but radical steps, guided by a long-term perspective, which can be acquired by questioning mindsets and being open to unorthodox ideas and actions.

3. Give room to diversity and flexibility. The future can neither be predicted nor planned. Options should therefore be kept open by exploring multiple pathways when working on strategies and actions. Resistance and barriers should be anticipated, and diversity fostered. Involving a variety of perspectives will enable cross-fertilisation and prevent 'tunnel vision'.

[66] Dutch Research Institute for Transitions, Erasmus University Rotterdam

4. Co-create: Neither local government, nor any other single actor can address sustainability challenges on its own. A variety of people and organizations make decisions that influence the future on a daily basis. As a local government, it is important to engage multiple stakeholders beyond simply providing input – everyone can be considered a decision maker, contributing their positions and perspectives.

5. Give room to change agents: Achieving ambitious targets is difficult when vested interests and positions are taken as a starting point. Therefore, actors who are already adopting new or alternative ways of thinking and doing (change agents) should be found, as they can be influential in mediating and triggering transitions. They should be actively engaged and supported with the resources and opportunities needed to realize innovations.

6. Facilitate social and institutional learning: Learning is essential for societal change. Opening up to actors with different backgrounds provides better insights into the challenges of and opportunities for change. The aim is short-term action aligned with a long-term vision to learn about new practices and current constraints. Learning processes should be supported by providing time for reflection and creating a setting that supports mutual trust and openness.[67]

The Transition Management proposes a cyclic process with the 4 phases implemented at different levels: strategic, tactical, operational and reflexive.

[67] DRIFT, Transition management in the urban context guidance manual, 2014

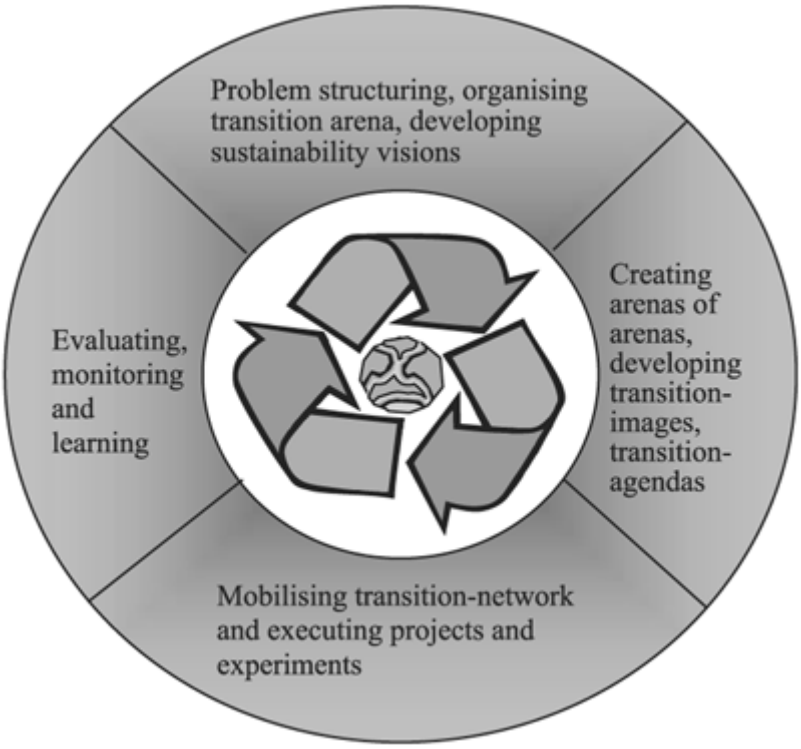


Figure 28: Transition Management Cycle (D Loorbach, 2007).

Mainly, TM steps as Transition Teams and Transition Arenas are effective instruments to shape a participatory process. On one hand the Transition Team is the core team that manages and facilitates the TM process in a multifunctional and transdisciplinary way[68]. On the other hand, the Transition Arena is one of the main results of the TM process and provides the framework to put into practice transition experiments. Finally, a reflexive phase is required in order to evaluate all the process, to identify new problems and challenges and to define future trajectories and actions. All the things considered, the TM processes can be adopted as a valid support for implementing transition process towards sustainability.

[68] Lang DJ, Wiek A, Bergmann M, Stauffacher M, Martens P, Moll P,Swilling M, Thomas C, 'Transdisciplinary research in sustainability science—practice, principles and challenges'. 2012

Level	Phase	Process step	Actions
Strategic	• Problem structuring • Organizing a transition arena	• Transition Team • Investigating the context • Community engagement	• visioning, • strategic discussions, long-term goal formulation
Tactical	• Framing the transition challenge • Development of long-term visions	• negotiating, • networking, • coalition building	• agenda-building, • backcasting
Operational	• Experiments and • mobilizing actors	• processes of experimenting, implementation	• Operational activities • Experiments • Projects development
Reflexive	• Monitoring and • evaluation	• Analysis and interpretation of results • imagine and understand • alternative trajectories for future action	• Evaluating experiments • Learning

Owing to their potential for system innovation change, several ST research fields underline the importance of transition experiments, also called niche experiments. The concept of niche is wide-spread. In the transition perspective, niches are small-scale protected space that could be a beginning of radical innovation.[69] Especially, niches have specific application domains such as buildings, energy supply, transport, food production. Consequently, the implementation of

[69] Kemp, R., Schot, J.W., Hoogma, R., 'Regime shifts to sustainability through processes of niche formation: the approach of strategic niche management', Technology Analysis & Strategic Management, 1998.

transition experiments in a new application domain can constitute a crucial issue in order to support the emerging need to make sustainability transitions happen.[70]

It is clear that the approach of transition as it works for the city even more works in the university context as the variety of actors involved, several sustainability challenges can be crucially practiced at level of university.

7.4 A means to reach the goal: Success project – Synergetic University Campuses boosting climatE innovationS into Society

The vision of this project is that university campuses can be considered small cities, they face similar challenges and usually approach them in the same conventional ways cities do. However, on campus the most brilliant minds are present, ready and able to face the challenges.

The aim of this project is to create a powerful innovation engine, that means a self-sufficient pan-European campus-network in which climate innovations are effectively developed within the local campus environments by exchanging knowledge, skills, expertise and means available. This engine will first bridge central university services – being the demand side – and the scientific activities being research and education – the supply side. But as soon as it runs smoothly, it will be a true bridge between campus and society proving innovations to be able to drastically reduce CO2 emissions on campus unleashing enormous market potential.
To get to this Innovation Engine 4 sub goals should be reached:

1. **Establish a Transition Team on each campus** to articulate local climate innovation demand, collect local data, execute the benchmark and forthcoming customized innovation strategy and exchange new climate innovation (tools) with other TTs. The TTs will actively exchange and

[70] Francesca Cappellaro, Alessandra Bonoli - Transition as a new participatory approach for achieving the sustainability of the university system.

connect the appropriate professors, courses and business partners; and when applicable incubators, business parks and the local government will be involved. As the TT is essential to reach the goals above it should represent the whole campus community and get the means to make things happen.

2. **Create a European network of 'living labs'** to be able to develop climate innovations from concept to consumer product on or close to campus. Lessons learned in setting up and managing such a living lab will be shared. More importantly, the infrastructure will be developed to pilot innovations in different countries to face different contexts, climates and niche markets. Finally, these living labs will be the key connection between science and society: (inter)action research can be done together with the market. As can be read in the profiles of the universities a fruitful basis is present already to get this network to a high level.

3. **Develop and build the Campus Transition Toolkit** to integrate workflow, reporting, monitoring, assessment and communication. Key elements of this toolkit will be a potentially everextending shared database that will be used, filled and renewed by the Transition Teams; a benchmark to be able to compare all collected data and formulate a strategy and focus for each campus; a dashboard to visualize the progress of the different campuses in an attractive way; and assessment tools to automate and manage selection of new transition team activities and to create a filter for new partners in the future.

4. **Generate revolving funds** to make the campus network financially self-sufficient. As the toolkit and its different elements have numerous commercial possibilities these should be structurally used to be able to keep the Innovation Engine running.

The development of an innovative Campus transition toolkit get and keep the engine running. Key element of this toolkit will be a potentially ever-expanding database, a benchmark, a dashboard and an assessment tool.

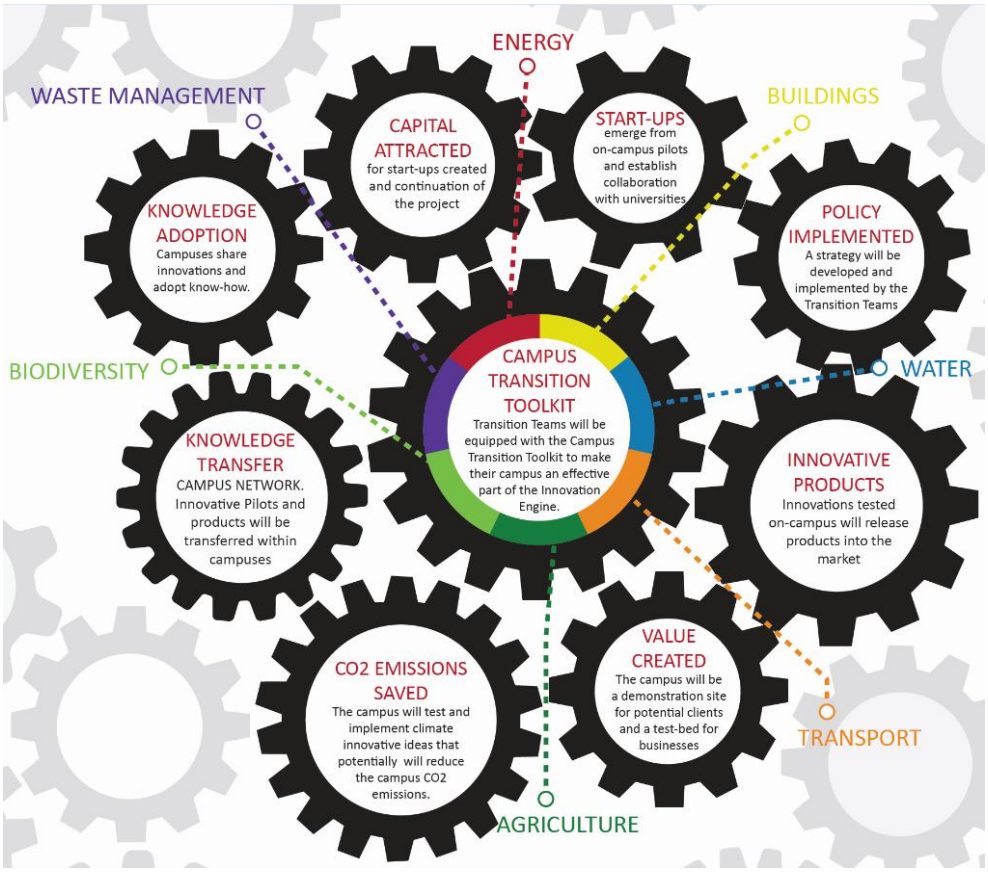


Figure 29: SUCCESS Project KPIs.

All campuses transition teams together will facilitate the campuses to create synergy by sharing knowledge, experience and processes. Herewith KPI's will effectively be met and local demand easily satisfied.

The project can roughly be divided into 3 years. In the first year establishing Transition Teams on each campus and creating a communication infrastructure will be key. The second year the Campus Transition Toolkit will be developed closely related to the strategies each campus has defined for its TT. The final year all results will be used to create a financially sustainable Innovation Engine.

Herewith KPI's will effectively be met and local demand easily satisfied.

- Knowledge transfer: Transition teams will be created so that they actively shape an innovation context for each campus that works best to face the local challenges effectively;

- New start-ups: Resulting from this project, start-ups will be created from on-campus pilots and will establish collaboration with universities;

- Capital attracted: Continue and enlarge the campus network as well as for start-ups resulting from this project;

- Policy standard implemented: A strategy will be developed and implemented by the TTs in each campus;

- Innovative product/services: Innovations tested on-campus in the course of this project will realise product into the market;

- Value created: New business model will be created to launch product/services, which will estimate the value created resulting from the future product/service implementation;

- CO_2 emission saved: An update on the estimated emission reductions that will result from the campus testing and implementation of climate innovative solutions.

7.4.1 Insight into Key Performance Indicators

Measurement of progress against agreed performance indicators enable a university to benchmark against others, but more importantly, against the sustainability targets for itself.[71]

The Success' KPIs in agreement with Innovation Pillar Guidance of Climate KIC can be divided in three types:

[71] Shriberg, M. Institutional assesment tools for sustainability in higher education: Strength, weaknesses and implication for practice and theory.

- Progress KPIs, indicates progress/contribution towards targeted outcomes and are normally expected to be achieved during project implementation:
    - Knowledge adoption
    - Knowledge transfer Agreement

- Outcome KPIs, describes the outcomes Innovation projects should target, as they contribute directly or indirectly to the creation of economic activity with climate impact:
    - New/improved product/service
    - New start-up
    - Capital attracted
    - Policies/standards implemented

- Impact KPIs, indicates the impact resulting from activities
    - CO_2 emission reduced (mitigation projects)
    - Value created/saved (adaptation projects)

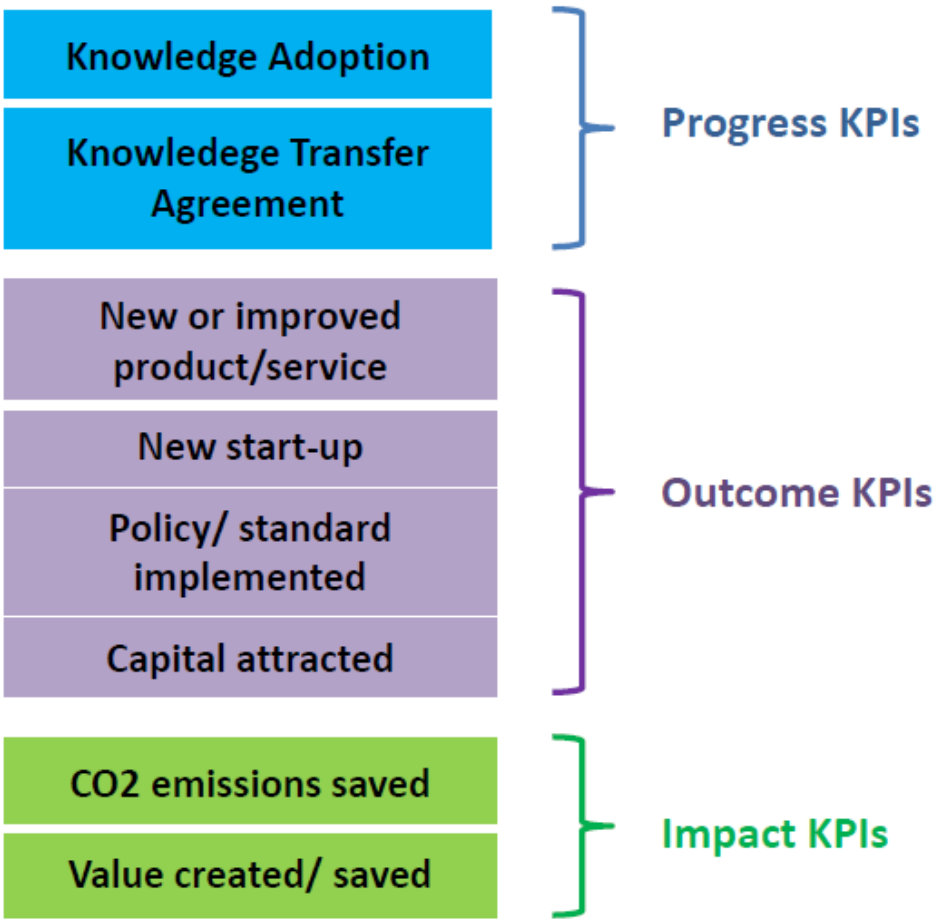


Figure 30: 7.4.1 Insight into SUCCESS Key Performance Indicators.

Knowledge adoption

Transition Team will be created so that they actively shape an innovation context for each campus that works best to face the local challenges effectively. In addition an instrument will be developed (Campus Transition Tool) in order to share knowledge among campuses and adopt innovations to implement on campus to lower the carbon emissions.

Knowledge transfer agreement

Knowledge Transfer will take place when partners of this project share created knowledge assets (innovative pilots and products) to another partner or sell this knowledge to a new member that wants to belong to the campus network created for cash or in-kind contribution.

Capital attracted

Capital attracted to continue and enlarge the campus network as well as for start-ups resulting from this project.

New or improved product/service

Innovations tested on-campus in the course of this project will release products into the market.

New start-up

Resulting from this project, start-ups will be created from on-campus pilots and will establish collaboration with universities. The start-up should be incorporated in the reporting years that take this project, or operate actively in the same years.

Policy/Standard implemented

A strategy will be developed and implemented by the TTs in each campus.

Tones of CO_2 emission reduced (mitigation)

An update on the estimated emission reductions that will result from the campus testing and implementation of climate innovative solutions.

Value created

New business models will be created to launch products/services, which will estimate the value created resulting from the future product/ service implementation.

7.4.2 Metric

Not all environmental or sustainability aspects and impacts are equally important, determination of their significance is necessary to enable prioritisation of responses, for example through sustainability action plans. In this part is

analyzing a metric to understand the qualitative evaluation of the significance of KPIs for both universities.

For this reason, a survey was conducted with people who play crucial roles for sustainability within the two universities and asked them to evaluate the KPIs of the project.

In particular, for each KPI was asked to choose between the following alternatives:

- Crucial, that means university is committed to undertake major efforts to achieve it;
- Important, that means it is one of the strategic objectives of the university but with lower priority.

The cases "Not important" was deliberately not taken into account as each KPI has already selected from a set, moreover each KPI aims to achieve results in the field of sustainability and thus are all believed to be important.

	UNIBO			TU DELFT	
	Crucial	Important		Crucial	Important
Knowledge adoption		X		X	
Knowledge transfer Agreement		X			X
New/improved product/service	X				X
New start-up	X			X	
Capital attracted		X		X	
Policies/standards implemented		X			X
CO_2 emission reduced (mitigation projects)	X			X	
Value created/saved	X				X

The table clearly shows that for TU Delft Impact KPIs (green) are crucial, so they represent the main target so the major efforts will be used to achieve them. On the other side Progress KPIs (blue) are Important but not Crucial, that means they represent one of the strategic objectives of the university but with lower priority compare to Impact KPIs. Regarding Outcome KPIs (violet) priority was evidently given to new/improved product/service and new start-up.

For University of Bologna, the situation is more homogeneous, the table shows that for each KPI type(Progress, Outcome and Impact) were chosen both "Crucial" and "Important", therefore the analysis do not show a clear distinction of priority.

In the table below were highlighted three different cases:

- Red: represent a KPI crucial for both universities
- Orange: represent a KPI crucial for one of two universities and important for the other
- Yellow: represent a KPI important for both universities

	UNIBO		TU DELFT	
	Crucial	**Important**	**Crucial**	**Important**
Knowledge adoption		**X**	**X**	
Knowledge transfer Agreement		**X**		**X**
New/improved product/service	**X**			**X**
New start-up	**X**		**X**	
Capital attracted		**X**	**X**	
Policies/standards implemented		**X**		**X**
CO_2 emission reduced (mitigation projects)	**X**		**X**	
Value created/saved	**X**			**X**

This table is relevant because represent the foundation to develop a strategy to create a true collaboration.

True collaboration requires a commitment to shared goals, a jointly developed structure and shared responsibility, mutual authority and accountability for success, and sharing of resources, risks, and rewards. Here's a definition.

> "Collaboration is a mutually beneficial and well-defined relationship entered into by two or more organizations to achieve common goals."[72]

However decide to work together, it's important that everyone understands and agrees to the purpose of the collaboration, the degree of commitment required, and the expectations of partners involved in the effort.

The table below illustrates a strategy for each case, in particular:

- Cooperation (Yellow): Exchanging information, altering activities and sharing resources for mutual benefit and to achieve a common purpose. Increased organisational commitment, may involve written agreements, shared resources can involve human, financial and technical contributions. Requires a substantial amount of time, high level of trust and significant sharing of turf.

- Coordination (Orange): Exchanging information and altering program activities for mutual benefit and to achieve a common purpose. Requires more organisational involvement than networking, higher level of trust and some access to one's turf.

- Collaboration (Red): Exchanging information, altering activities, sharing resources and enhancing each other's capacity for mutual benefit and to achieve a common goal. The qualitative difference to cooperating is that universities and individuals are willing to learn from each other to become better at what they do. Collaborating means that universities share risks, responsibilities and rewards. It requires a substantial time commitment, very high level of trust, and sharing turf.

[72] Carolyn Parkinson, Building Successful Collaborations, Cambridge & North Dumfries Community Foundation, 2006.

Particularly, the following table adapted from the works of Martin Blank, Sharon Kagan, Atelia Melaville and Karen Ray explains the key points of these three strategies, based on the importance that each KPI has for the universities, with detailed regard on commitment, responsibility, authority, accountability , and sharing of resources, risks, and rewards.

Cooperation	Coordination	Collaboration
• Informal relations	• More formal relations	• More pervasive relationship
• No clearly defined mission	• Focus on specific effort or program	• Commitment to a common mission
• No defined structure	• Focus on a specific effort or program	• Result in a new structure
• No planning effort	• Some planning	• Comprehensive planning
• Partners share information about the project at hand	• Open communication channels	• Well-defined communication channels at all levels
• Individuals retain authority	• Authority still retained by individuals	• Collaborative structure determines authority
• Resources are maintained separately	• Resources and rewards are shared	• Resources are shared
• Lower risk	• Higher risk	• Greater risk
• Lower intensity	• Some intensity	• Higher intensity

Therefore for each KPI has been identified a strategy:

- KPIs Yellow
    - Organization mission and goals are not taken into account
    - Relationship are informal, each university functions separately
    - No joint planning is required
    - All authority and accountability rests with the individual universities which acts indipendendly

- Resources (staff, time, money, capabilities, etc) are separate, serving the individual organization's needs.

- KPIs Orange

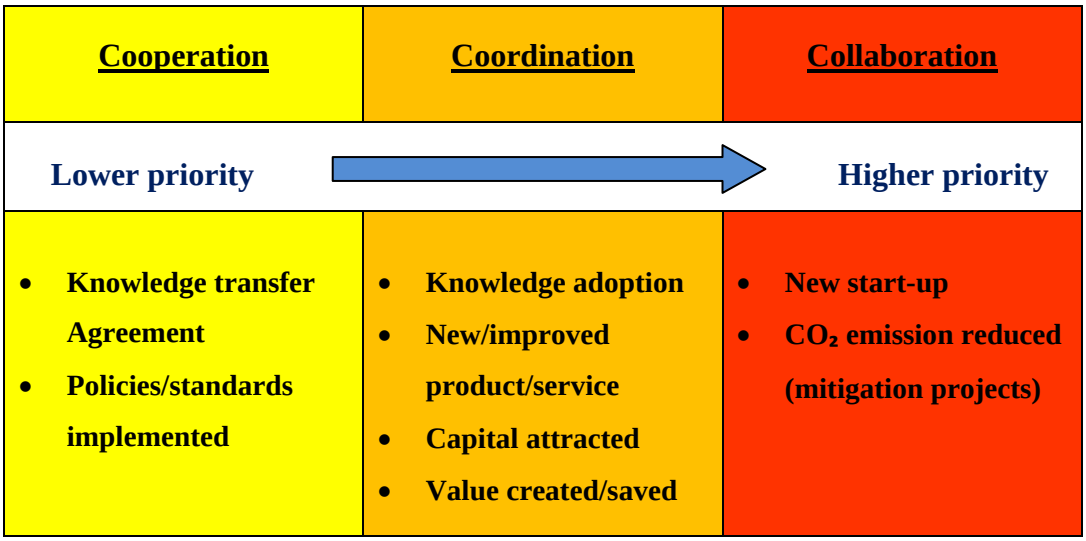
  In this case it is clear that one of the two universities will use more resources to the achievement of KPIs, consequently the other universities will play a secondary role by absorbing knowledge.

  - Mission and goals of the individual organizations are reviewed for compability
  - Communication role should be established and definite channels are created for interaction
  - Authority rest with the individual university, but there is a coordination among participants
  - Resources are acknowledged and can be made available to others for a specific project

- KPIs Red

  Collaboration involves synergy. When universities work together toward a joint goal, they can accomplish something larger, greater, and with more impact than something done in isolation

  - Common, new mission and goals are created
  - New organizational structure and/or clearly defined and interrelated roles that constitute a formal division of labor are created
  - Authority is determined by the collaboration to balance ownership by the individual organizations with expediency to accomplish purpose
  - Resources are pooled or jointly secured for a longer-term effort that is managed by the collaborative structure



7.4.3 How the establishment of a transition team on each campus can help to achieve crucial KPI

Since the crucial KPIs were identified for each university and was identified a collaboration strategy for them is now possible to analyze the first sub goal of the project (Establish a Transition Team on each campus) to show how this can help to achieve the objectives.

A transition team is a group of person that avail the Transition Management approach for steering transitions towards socially needed directions. The creation of a sustainability transition team with representation from students, academic and operational staff is for all practical purposes essential. The transition team may also include representation from external stakeholders for example the local community, government bodies and/or significant local employers of the university's graduates.

In order to build coalitions, transition team in each campus can activate a participative process among actors that recognize the benefit of joining forces in performing innovative experiments.

In order to enable a form of cooperation for the Crucial KPIs is necessary that from each transition team, members are exchanged, from Delft to Bologna and vice versa from Bologna to Delft, in order to always have new points of view and

aim of exchanging experiences from one university to the other one. To this end, it would be convenient that every team was placed in a specific place in which it lives and works.

This synergetic exchange has the objective to facilitate and speed up the development of sustainable innovations in particular through the establishment of a transition team in each campus the collaboration strategy can find a rich soil to implement new project, and to reach the main KPI namely "CO_2 emission reduced" and "New start-up". Accordingly, each university can contributed in its own unique way by exchanging best practices, pilot facilities and innovations as is possible to see in the picture below.

Figure 31: Synergetic exchange between Delft University of Technology and University of Bologna

8 Conclusion

This thesis has laid out the reasoning for which university adopts strategies to address sustainability, specifically through the development of an international collaboration between universities.

The study conducted on the two universities showed that in recent years there has been a clear sign of the fact that strong efforts to achieve sustainability have been implemented. In different ways they can show great strengths. For instance, TU Delft is very ambitious with regards to the reduction of energy consumption. UNIBO on the other hand is an example to follow as it has developed a strategic plan for sustainability.

Despite this, both universities different barriers are emerged, such as technological barriers that limit the implementation of sustainable practices due to lack of knowledge and competences. Then institutional barriers affect the organization and employees structures in the hardly adoption of holistic approach and interdisciplinary projects as sustainability requires.[73]

At this point, it is strongly recognized the urgency to adopt a transition approach for achieving sustainability. The Transition Management approach is an instrument that can contribute to identify a holistic approach for the transformation of the entire university system. Particularly, the establishment of a transition team and the creation of a living lab can address issues related to ecological, human health and socio-economic impacts. Working with faculty, researchers, and staff from around the campus, creates academic integration throughout the university – simultaneously helping to educate students and engaging in the development and analysis of innovative approaches to diminishing the university's environmental impact.

In conclusion, the university system provides the context for a major transition within most students' lives. They can be exposed to a broad range of lifestyles and influences and imparted with the knowledge of professional ethics, that will have lasting effects on the choices they make in their lives. Additionally, many

[73] Cappellaro, F. de Werk, G., Nagel, J., Bonoli A., Spada, M. Sustainable Campus Initiatives for boosting Low Carbon Innovation. Journal of Cleaner Production (approved)

universities have very extensive ties with government and industry, and through start-up companies and allied research institutes serve as incubators for research and development. These factors combine to make the university perhaps the most significant cog in the machine known as society. Although there already are individual efforts at many universities to make campus operations, the curriculum, and research opportunities more geared towards sustainability, these efforts need to be pulled together, normalized, and focused into a resource base that can serve a greater number of universities.

Moreover, as the "SUCCESS" project shows, campuses can be considered small cities facing the same sustainability challenges. In principle, a campus contains all the ingredients to face these challenges as the most brilliant minds on earth are educated there. More importantly, a lot of elements are present in the campus context to generate serious innovations to meet the demand that comes with the challenges like engineering courses; business challenges and competitions; living labs and incubators; and the whole network universities usually have include international companies and governments.

Finally, a campus is much easier to manage than a complete city as it 'just' has a management instead of a complete government, and temporary inhabitants instead of citizens. The story is completed with the fact that science, and in particular the vision of the university as a living lab can drive innovation, which means that campuses are the best place to develop innovations as well as testing and launch them, not only for the university itself but also for the entire ecosystem.

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