

Conference report

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Urban Futures: the Challenge of Sustainability





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Key messages

Demographic trends

- The world will have to make living space in **cities for 3 billion more people** in the next 50 years—double what we have today.
- Half of this urban population growth in the next 15 years will be in **small cities** with fewer than 500,000 inhabitants.
- In the developing world, cities are places of opportunity, they generate jobs, provide opportunities for investment, and offer hope for change. Cities are the major contributors to national GDP.
- These demographic trends underline the need and opportunity to implement sustainability in cities that have not yet been built. These new cities will contribute greatly to the **urban ecological footprints** of developing nations.

Energy and city governance

- If we are to reach a low carbon society for all in time to avoid the worst effects of climate change, we need an **urgent and massive transformation**—we need not only new energy infrastructure and technology, but significant economic and social changes in our use of energy.
- Globally, **two thirds of energy consumption occurs in urban areas**, and the energy consumption of urban populations in developing countries is soaring, tightly linked to economic growth.
- There is an urgent need for better energy policy and planning at the urban scale. Insufficient power to determine policy restricts the ability of **city and municipal governments** to implement sustainability plans.
- Economic growth is closely linked to improvements in transport systems and increasing mobility of people and goods, and industrialized countries heavily subsidize both public and private transport. **Can we maintain economic productivity in industrial countries without increasing mobility?** Or can we maintain

growth in mobility whilst at the same time avoiding the negative costs through improved technology?

Poverty and social equity – improving inclusion

- One unacceptable result of present trends is the very fast growth of **slum populations**. In 2050, two billion people are predicted to live in slums, which will be two-thirds of the expected urban population at that time. These projections are based on “business as usual” - but this does not have to continue.
- People live in slums for many reasons, including cheap housing, proximity to employment, and social and cultural exchange. Slums have very productive, though informal, economies that could be **vital components of national economies**, if properly recognized and incorporated into the formal system.
- **Education** for all, at all levels, is a critical component of sustainable urban development and is an exceptional challenge.
- **Social inclusion** is essential—poor people must be treated as actors rather than recipients of aid.

Design for social sustainability

- Urban designers need to rethink land use and the horizontal division of functions, and try to create **compact, efficient cities**.
- Urban planning must implement **integrated strategies** that consider the overall productivity of financial, human, and natural resources of cities, because the current model of sectoral planning does not work.
- Architects cannot design social cohesion. But they can design breeding grounds for **social sustainability**, upon which the concept of the ‘open city’ is based.
- **Open city** designs take the existing status of a city as the starting point from which transformation begins.

- Designs and plans must be **flexible at all levels**, so that neighborhoods can grow and develop organically.
- There is no **single technology or system that will be the key to making buildings sustainable**. However, dramatic improvements could be made merely by implementing technologies that are already available.

Environment and material flows

- Although urban ecosystems account for only 2–4% of the earth’s land surface, their environmental impacts are far reaching. The urban socio-ecosystem is a strong driver of environmental phenomena at the global scale—it produces waste and carbon dioxide emissions and appropriates huge amounts of resources including water, food, fuels, building materials.
- Analyzing the material flows of cities allows us to design policies to reduce resource use, emissions and waste, and **close material loops** by recycling and reuse.
- **Modeling resource flows** in urban areas enables the outcomes of alternative planning scenarios to be evaluated.
- We need **fully resource-recycling systems** in place of water and sanitation systems that are linear, releasing water and nutrients out of a city.
- Increased **urban-rural harmonization**, through closed material cycles, ecological networks, and community-based initiative, will lead to more sustainable city regions.

The role of universities

- **Integrated, interdisciplinary research** in needed to help cities develop sustainably. This requires not only engineers, designers, and natural scientists, but social scientists, political experts, and external partners, to find a common understanding of shared problems, and jointly agree and collaborate on new ways to find solutions.
- Solutions will only be identified and implemented if researchers **interact closely with external partners**. Interactive tools and spaces enable participatory dialogues and plans.
- **Students** tackle the urban futures challenge with innovative solutions if they are offered the right education opportunities and environment: for example by immersion in local communities, by interaction with experts in design research studios, and by developing integrated methods and models together with policy makers and other end users.

Technological innovation and business opportunities

- **Pathways** to change towards a low carbon society by 2050 will be based on **bridging technologies** that consider existing infrastructure as an opportunity rather than a limitation.
- Regulation must enforce urban planning that uses **forward-thinking design**, to predict future technologies.
- Technologies are already available to **reduce the energy intensity of cars and aircraft by 30–50%**—but environmental gains through this increased efficiency will almost certainly be lost by people increasing their travel.

Foreword by the President of ETH Zurich



The AGS is a partnership of four leading science and technology universities—MIT, the University of Tokyo, Chalmers University of Technology, and ETH Zurich—and their partners. It was formed in the conviction that closer collaboration amongst leading research institutions, and partnership with government and industry, are essential for achieving progress towards sustainability. Since its foundation in 1997, AGS has promoted many important research projects and provided intellectual leadership to help societies improve both environmental quality and the quality of life.

The theme of the 2009 AGS Annual Meeting was the dramatic growth in the world's urban population, and the potential threats and opportunities this poses for sustainability. We had an exciting program of lectures, workshops, discussions and posters that illustrated the crucial role that universities have to play in addressing the challenge of urban futures. For example, the poster session highlighted a wide range of innovative solutions to questions of energy, mobility, water and urban agriculture, policy and governance, sustainable construction, education for

sustainable development, and urban sustainability indicators. In planning this conference, our aim was to provide a forum for all those concerned about our urban future, whether from academia, industry or public administration, at which new ideas can be discussed and new collaborations planned.

Speakers from the AGS partner universities showed how research programs at each university are tackling the challenge, including research for sustainable urban futures, and pathways to sustainable energy systems. The energy panelists were united in their message. Globally, most energy is consumed in cities. If we are to reach a low carbon society for all in time to avoid the worst effects of climate change, we need an urgent and massive transformation not only in our urban infrastructure and technology, but also significant economic and social changes in our use of energy. AGS speakers emphasized that the urban futures challenge must be tackled with an integrated, interdisciplinary research approach taking into account the dynamics of the cities (flows of energy, water, people, and waste). This requires not only engineers, designers, and natural scientists, but social scientists, political experts, working together with external partners, to find a common understanding of shared problems, and jointly agree and collaborate on new ways to find solutions. Solutions will only be identified and implemented if researchers work closely together with external partners. Interactive tools and spaces enable participatory interactions and synergies with researchers, planners, local populations, government decision makers, and industry leaders.

Many of the achievements associated with AGS have come from our students. One of these is the World Student Community for Sustainable Development, which was formed as a spin-off from AGS graduate courses (the Youth Encounter for Sustainability – YES courses). I was therefore particularly pleased that the annual conference of the WSCSD was linked with that of the AGS, and that our program included joint events (see www.wscsd.org/s3zurich for details).

Ralph Eichler
President of ETH Zurich

Introduction by the AGS Faculty Coordinator at ETH Zurich



The year 2008 was a milestone in a process of urbanization that began several thousand years ago, but has accelerated greatly in recent times. For the first time, there were as many people living in towns and cities as in rural areas. By 2050—when the population is projected to reach over 9 billion—around 75% will be in urban areas.

Urbanization has many causes and many faces. In underdeveloped countries, already about one billion people live in slums without basic necessities such as clean water and sanitation, and lacking secure tenure of the land they occupy. In rapidly industrialising countries such as China and India, urban growth is fuelled by economic development that is outstripping the capacity of cities to provide basic infrastructure. The results are traffic congestion, environmental pollution, poor health and low life expectancy. And in some of the richest countries, a demand for larger houses and gardens is producing vast areas of urban sprawl, with people using an ever denser transport network to commute long distances to their places of work. Huge megapolitan regions are emerging, consuming small towns as

they grow, and causing fundamental changes to biogeochemical cycles and regional climates.

Visions of how cities will develop are equally diverse. Scenarios range from utter chaos as the urban areas and their surroundings are inundated by uncontrollable masses, to an optimistic, high-tech future in which major advances in science, technology, management and policy provide the tools needed to cope with the massive demographic shifts.

The AGS Annual Meeting 2009 was devoted to the challenges posed by this extraordinary growth of the world's urban population. Although this growth presents many acute problems, it is also a unique opportunity to move towards a more sustainable use of natural resources. As the former director-general of UNEP, Klaus Toepfer, once remarked, 'The battle for sustainable development will be won or lost in the cities'. With this idea in mind, two propositions guided the planning of the conference:

- that cities, properly managed, can be transformative arenas in which natural resources are used more efficiently, contributing to a high quality of life for everyone, and
- that reinventing cities offers one of the most effective ways to reduce human impacts upon the environment and achieve greater sustainability.

Through their research and teaching, universities have an essential contribution to make in tackling these great challenges. No single institution, however, has all the research expertise and local knowledge necessary to understand complex problems of sustainability; AGS provides a valuable multi-regional and multi-disciplinary network that extends the capability of the individual schools. In assembling the program, we were able to draw upon this wealth of expertise and contrasting regional perspectives.

Professor Peter Edwards

AGS Faculty Coordinator, ETH Zurich,
on behalf of the organizers



Sustainable Urban Futures: Challenges and Opportunities for Academia

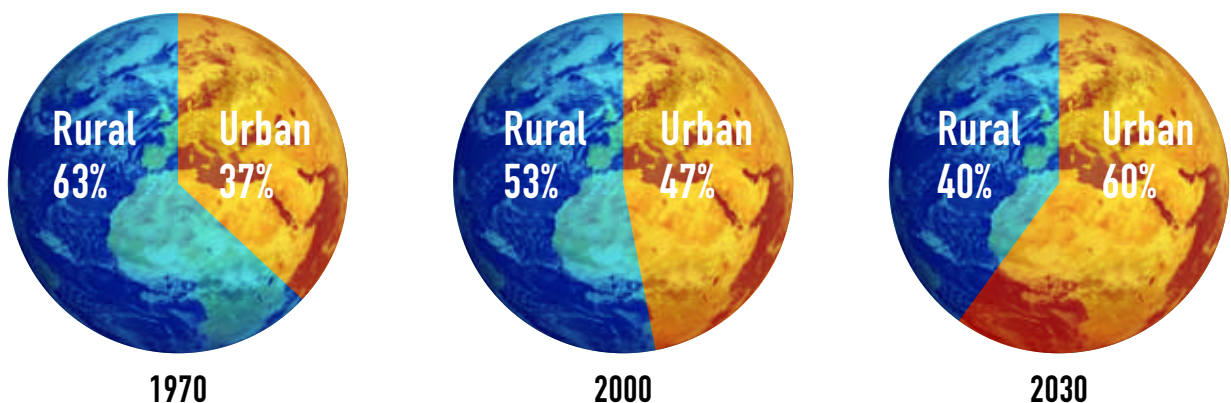
Lars Reuterswärd

Director of the Global Division of UN-Habitat



Unsustainable urban development is not a new issue. In the 1960s Buckminster Fuller coined the concept “Spaceship Earth”¹, in which he framed the problem of developing in harmony with our natural world, despite a rapidly increasing human population¹. In 1987, the Brundtland Commission report, “Our Common Future”², addressed urban challenges related to sustainability and recommended that research should provide a basis for rethinking the way cities are designed, built, and managed. Unfortunately, we have failed to address the issue of **urban sustainability** since it became apparent nearly 50 years ago, and the recommendations set forth by this report are still valid.

While we have largely avoided the topic of sustainability in planning urban regions, the problem has increased. In 2007, the rate of population growth in cities exceeded the rate of **population growth** in rural areas. This is a demographic change we have never seen before, and our current tools are not sufficient. The approaches we use are designed for slow—not fast—growth, and for affluent situations, while the majority of urbanization is, and will continue to be, in the undeveloped world. We will have to build cities for 3 billion more people in the next 50 years—double what we have today. This emphasizes the need and opportunity to implement urban sustainability in cities that have not yet been built. These **new cities** will contribute greatly to the urban footprint of developing nations.



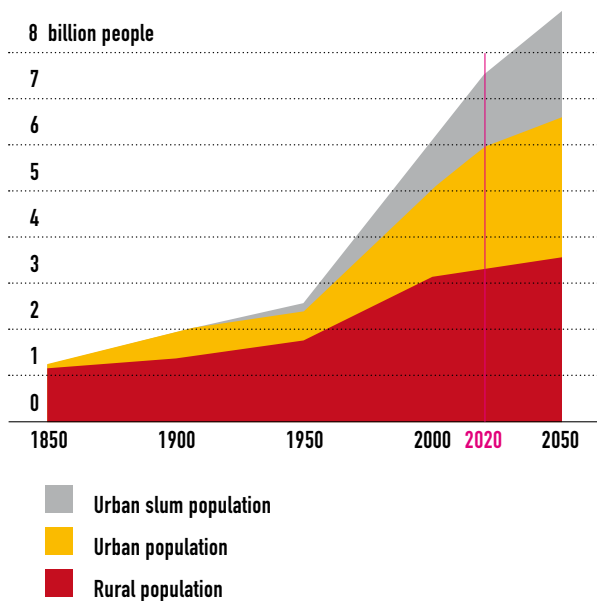
In 1970, one in three people lived in cities; in 2000, nearly half the global population lived in cities; and by 2030 approximately two-thirds of the global population will live in cities.

¹ Buckminster Fuller, R. (1969) Operating Manual for Spaceship Earth. New York: E.P. Dutton & Co.

² WCED (1987) Our Common Future. Oxford University Press, Oxford, UK.

One unacceptable result of present trends is the very fast growth of **slum populations**. In 2050, two and a half billion people are predicted to live in slums, which will be one third of the expected urban population at that time. Currently, an average of 75,000 people move into slums every day, and the Millennium Development Goal Target 11³—to achieve a significant improvement in the lives of at least 100 million slum dwellers by 2020—is grossly inadequate. Even if this goal were achieved, 1.3 billion people would still live in slums in 2020. UN-Habitat calls for a halt in slum population growth and a reduction of 600 million slum dwellers by 2020. Additionally, quality of life in slums must be improved.

Population of The World



In 2000 1 billion people lived in slums. By 2050 it is predicted that we will have 2.5 billion people living in slums.

A slum, by definition, lacks at least one basic factor of quality of life: improved water and sanitation, sufficient living area, durability of housing, and security of tenure⁴. One example of a city with a huge slum population is Nairobi, Kenya, where 60% of the population occupies 5% of the city's area; this

is more or less equivalent to the amount of area allotted for golf courses in Nairobi. Projections of slum population growth are based on “business as usual,” but this does not have to continue—if we are able to build and maintain golf courses, we can improve the inadequate living conditions of the majority of the population. It is important to realize that people live in slums for many reasons, including cheap housing, proximity to employment, and

We need to rethink urban sustainability to effectively address the problem of urban and slum population growth.

social and cultural exchange. Slums have very productive, though informal, economies that could be vital components of national economies, if properly recognized and incorporated into the formal system.

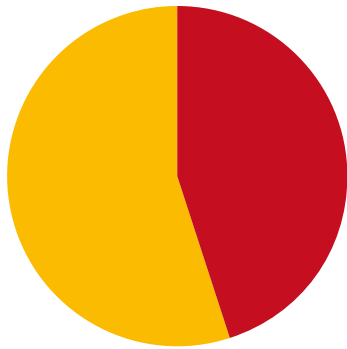
Another feature of urban population growth that is often over-looked is that most of the global urban population lives in small cities with less than 500,000 inhabitants, and this is where half the urban population growth is expected to occur in the next 15 years. The main challenge for development lies in supporting the **small- and medium-sized cities**. Mega-cities, mainly in the developing nations, are also expected to grow, but they have access to a greater diversity of tools and resources and are largely able to manage their growth.

Despite the challenges of urban sustainability, it is increasingly clear that **urbanization is the best solution to global population growth**. We cannot and should not fill our agricultural land with large numbers of people. If people live in well-managed urban regions, they can live more densely and benefit from services, education, and industry. Regardless of the challenges of sustainability, cities hold the hope of economic development and social wellbeing in many undeveloped nations. **Cities are places of opportunity**, they generate jobs, provide opportunities for investment, and offer hope for change.

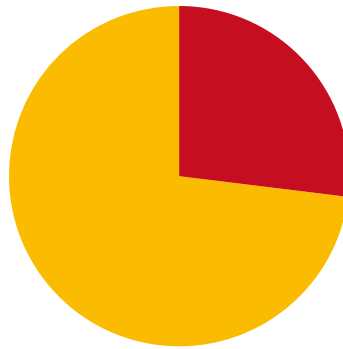
³ UN Millennium Project (2005) Investing in Development: A Practical Plan to Achieve the Millennium Development Goals. New York. <http://www.un.org/millenniumgoals/bkgd.shtml>

⁴ UN Habitat (2003) The Challenge of Slums: Global Report on Human Settlements. UN Habitat, Nairobi, Kenya.

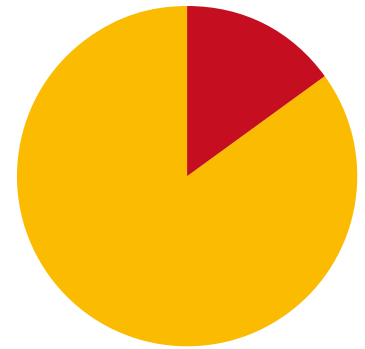
GDP produced by cities in developing nations



GDP produced by cities in developed nations



GDP produced by cities in high income countries



■ GDP from cities

■ GDP from other

Cities are the drivers of national economies: they are places of opportunity, culture, public facilities, and investment.

In order to improve urban sustainability in the developing world, we need to address three major challenges within appropriate timeframes. In the short-term, quality of life for people living in slums has to be improved. This will help a great deal but not solve the problem (because slums are invariably located in the wrong place), and therefore must be followed by—and conducted in coordination with—the mid-term goal of providing cheap, serviced, well-located land and financing so that people can move out of slums. Finally, in the long-term, we must design more resilient urban habitats.

In the future, cities must move from sustainability to resilience to regeneration.

Successful tools and strategies for improving urban sustainability should address these issues:

- Cities must be **economically productive**—poverty limits investment.
- Successful solutions must deal with the issue of **equity**. Social conflicts are inevitable where the very rich are the minority and most people live off one or two dollars per day. Inequity is a challenge because it requires subsidies from the rich to the

poor, as well as between current and future generations, which must operate over the right timeframe to ensure that the benefits are not short-lived.

- **Education for all**, at all levels, is a critical component of sustainable urban development and is an exceptional challenge. There are many people in the world who cannot read or write. However, regions where the population has been educated are elevating themselves out of extreme poverty and stagnation.

Furthermore, the general challenges of sustainable urban development will be magnified by **climate change**. Many of those who will be most affected live in cities in the arid areas or coastal regions of developing nations. These areas are not only experiencing massive urban growth, but will become increasingly susceptible to climate-induced catastrophes, including rising sea level, landslides, drought, and extreme weather events. These are challenges we have never faced before.

We cannot simply do more of the same—we **need new thinking and new tools** to manage this huge change. Much of what is built in the developing world is influenced by what has already been built in the industrialized world. For example, the unequal distribution of property between the dense city center and the vast suburbs of Houston, Texas, represent the same urban model as Nairobi, Kenya. This

sprawling city model is completely unsustainable and will lead to serious social friction when economic growth is slow. UN-Habitat needs universities to provide critical analysis and good models for more sustainable urban planning. In return, UN-Habitat can propagate tools, help cities and nations to use them, and create agreements on how to consider future development.

The structure of cities will define human behavior forever.

Urban planners need to rethink land use and the horizontal division of functions, and try to create **compact, efficient cities**. A McKinsey report⁵ found that by concentrating urban growth in dense cities, which function as hubs central to clusters of medium- and small-sized cities, per capita GDP can increase by 20%, and public spending needs are reduced because of more efficient use of resources and infrastructure, such as public transport. Consequently, if you want a city to be productive, you must consider urban morphology and how it contributes to the city's long-term economic growth. In order to do this, we need reality-based, culturally sensitive urban growth models that predict the development of informal settlements, such as the ISGM model (Sietchiping, 2005⁶).

Urban planning must implement integrated strategies that consider the overall productivity of financial, human, and natural resources of cities, because the current model of sectoral planning does not work. For example, in place of water and sanitation systems that are linear, releasing water and nutrients out of a city, fully resource-recycling systems are needed.

Many research networks around the globe, such as the AGS, work on the topic of sustainability. However, the majority of these networks only include members from affluent nations. The Sustainable Urban Development Network (SUDNet), a network created by UN-habitat, aims to develop and expand existing networks to include developing nations and regions that are currently left out, so that they can benefit from the insights gained. If universities in developing countries have well trained professionals training future leaders, they can become centers of regional development. SUDnet links UN-Habitat Partner universities with emerging universities through reality-based research projects centered on sustainability. For example, Chalmers University of Technology (Sweden) and Maseno University (Kenya) are investigating application of low-cost, low-key, "quick and dirty" methods to improve quality of life for residents in Kisumu on the shores of Lake Victoria, such as bicycle pathways, which expand the radius of local people's economic possibilities.

⁵ UMcKinsey Global Institute (2008) Preparing for China's Urban Billion. McKinsey Global Institute.

⁶ Sietchiping, R. (2005) Prospective Slum Policies: Conceptualization and Implementation of a Proposed Informal Settlement Growth Model (ISGM). Third Urban Research Symposium on "Land Development, Urban Policy and Poverty Reduction", 4-6 April 2005, Brasilia, DF, Brazil. <http://www.worldbank.org/urban/symposium2005/papers/sietchiping.pdf>



Panel

Pathways to Sustainable Energy Systems: the Role of Research Institutions

The panel, hosted by the Energy Science Centre of ETH Zurich, discussed how the world's energy architecture can be transformed on an effective scale and considered the role of research institutions in meeting this challenge.

How big is the challenge?

If climate warming is to be limited to 2 or 3° C, the world has a **global emissions cap** or remaining “budget” of 1000 Gt of CO₂ equivalents⁷. If we continue to increase emissions as we are doing today, this budget will be used up by 2035. If the world in 2100 is to host a population of 10 billion living with a global prosperity level similar to that of Switzerland or Japan today, whilst staying within this global temperature boundary, emissions must be limited to 1 ton CO₂⁸ per capita per year for everyone. Japan's governmental pledge for 2050 requires a reduction from the current 10 tons CO₂ per capita to 3.4 tons in 40 years, and the European Union has made a similar pledge. At the same time, the per capita emissions of developing countries are increasing rapidly. For example, the reduction that the EU targets by 2020 is equivalent to the amount of emissions China will add to its energy system within the coming year.

Meeting these targets will be more difficult than most people realize. The **energy industry** is a highly capitalized, global business with enormous infrastructure and vertically integrated global supply chains, which supply essential services to all levels of society. It is also a highly regulated oligopoly, with prominent political interest and involvement. The necessary transformation will require not only

new infrastructure and technology, but also economic and social changes. The energy challenge has multiple dimensions (other than reducing CO₂ emissions), including local and regional pollution, energy security, fair access to energy services, competition for land use, demand for water and other materials, economic competition, and risks (such as radioactive waste or CO₂ leaks).

How do we know what the world will be like in the future, and how do we get there?

Our future energy use, and therefore our goal for change, depends on how the world's societies evolve. Scenarios are used to illustrate the different ways society could change, including population growth, economic growth, education, consumer preferences and lifestyles, circumstances of international collaboration and global economics, and the development and implementation of technology. Pathways are intended to show how changes can be achieved—at scale, in time and for all—in order to progress to a low carbon society.

Short term pathways—within two decades (2030)—must be based on commercially available technologies. **Medium term** pathways—in the next four decades (2050)—will be based on bridging technologies that consider existing infrastructure as an opportunity rather than a limitation. **Long term** pathways to a low carbon society—five or more decades (2100)—must to a greater extent rely on new energy technologies and systems. But how can we know what issues and knowledge will be relevant for society in 2050 or 2100? Researchers need to be prepared for surprises, and constantly correct the pathways.

Universities have a key role in showing society that **it is possible to achieve the low carbon society**, and also in communicating the urgent need for action. The Japan Low Carbon Society report demonstrated that Japan already has the technological potential to meet the government's emissions reduction target by 2050⁹. The report proposes that Japanese society can develop in either of the contrasting A or B scenarios, and that the target can be

⁷ IPCC (2007) Climate Change 2007 Synthesis Report. 4th Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland. <http://www.ipcc.ch/ipccreports/ar4-syr.htm>

⁸ Throughout the text, CO₂ is used as shorthand for CO₂ equivalents, calculated from all greenhouse gas emissions.

⁹ Japan Low-Carbon Society project (2008) Japan Scenarios towards Low-Carbon Society (LCS) - Feasibility study for 70% CO₂ emission reduction by 2050 below 1990 level. Revised edition May 2008. Japan National Institute for Environmental Studies. http://2050.nies.go.jp/project_e.html



Society A is technology-driven and innovative, and production is centralized with recycling of materials. Society A is focused on the urban and individualistic, and people have fast lifestyles oriented to comfort and convenience.



Society B is characterized by slower-paced and nature-oriented lifestyles, people are socially and culturally oriented. Society B is decentrally organized and community-based, with self-sufficient local production and consumption.

met in both. The ETH strategy shows how the 1 ton CO₂ per capita emissions limit can be reached by 2100, and outlines what energy research is needed to achieve that goal¹⁰.

What role can universities play in meeting this challenge?

- Identify and focus on key actions and transformation technologies

Buildings are the largest source of CO₂ emissions, particularly in the US where they are heated and cooled mainly using electricity generated from coal. All panelists saw an immediate potential to reduce emissions by more than half using existing technologies, e.g. lighting systems, electric appliances, and building envelopes. Investment in such technologies would bring substantial economic gains before 2030. With technologies using decentralized solar-thermal and ambient heat, heating and cooling in buildings, industry, and power generation, could be completely CO₂-free by 2100.

Transportation is the second largest source of CO₂ emissions, from petroleum, diesel, and aviation fuel. In the short-term, CO₂ emissions from transportation could be reduced with commercially available fuel efficient vehicles, including hybrid and electric cars, and new transportation policies. By

2100, short- and mid-range mobility could be completely supplied by CO₂-free electricity. Long-distance transportation (notably marine freight) will continue to require liquid fuels, but these could come from renewable biomass or non-carbon sources.

New and more efficient **energy conversion and delivery systems** that provide storage, high-quality power, and distributed generation (with significantly reduced CO₂ emissions) are essential. According to the ETH energy strategy, electricity becomes the backbone of the future energy system, meeting about half of all energy requirements, and distributed and stored in a robust, efficient, and comprehensive electric grid.

Better **design and planning methods** and **indicators** are crucial to improving energy, eco-efficiency, and sustainability of all energy consuming systems. Integrated design maximizes the output of energy and products and minimizes wasted heat, water, and materials, using methods such as life-cycle analysis, pinch analysis, and multi-objective optimization¹¹. Exergy efficiency is an indicator for comparing the overall energy efficiency of different technologies providing similar energy services. Exergy efficiency measures the efficiency of an energy conversion process as a proportion of the total energy that could be gained from that system (rather than as a proportion of the total energy that

¹⁰ ETH Energy Science Center (2008) Energy Strategy for ETH Zurich. ETH ESC, Zurich, Switzerland. February 2008. <http://www.esc.ethz.ch>

¹¹ Li, H., Maréchal, F., Burer, M. & Favrat, D. (2006) Multi-objective optimization of an advanced combined cycle power plant including CO₂ separation options. *Energy*, 31, 3117-3134.

goes into the system, which can never be completely captured into work). It can therefore be used to compare technologies that rely on different sources of primary energy (non-renewable or renewable), and whether they usefully capture the released energy. For example, the heating service provided from hot water heated by fossil fuels in a boiler has an exergy efficiency of 6%. Most of the energy is wasted. The same heating service could be provided by electricity from a combined-cycle power plant, supplemented by a heat pump, with twice the exergy efficiency.

The world has too much fossil fuel—enough to burn up the Earth—yet many countries are significantly increasing their use of fossil energy. **Carbon capture and storage** (CCS) will therefore be a crucial bridging technology to meet the medium term targets on emission reductions described above. The Pathways project at Chalmers investigates the role of CCS as part of a portfolio of mitigation options for the European stationary energy system. A typical operating cost for CCS will be in the order of 20 Euros per ton of sequestered CO₂ and the technology is scheduled to reach commercial scale in Europe by the year 2020. The most difficult challenge, however, is how to scale-up quickly enough; as an illustration of the magnitude of the problem, coal-fired power plants in the US are currently emitting close to 2 billion tons of CO₂ a year. Commercial implementation of CCS at such a scale will require adequate regulatory and liability structures.

Another example of a bridging technology studied in the Pathways project at Chalmers and ETH is the **partial electrification of transport**. Plug-in hybrid electric vehicles (PHEVs) have a high energy efficiency, and the part of their fuel produced from fossil fuels can be combined with CCS, thus approaching a zero (or near zero) carbon emission energy system. In the future significant opportunities will be created by linking the stationary energy system with the transport system. For example, PHEVs can act as power regulators by adjusting the

time of charging the PHEV batteries. This facilitates the efficient integration of intermittent electricity generation into the electricity grid.

- Interact with society and policy

Universities provide a unique environment in which interdisciplinary groups, including technical, social, and natural science expertise, can develop well-founded policy recommendations, as MIT publications demonstrate¹². Furthermore, because individual researchers often differ in their opinions and viewpoints, integrated expert groups can offer a spectrum of options and thus fulfill the role of **honest broker**.

An interdisciplinary academic analysis is, however, useless if it does not incorporate the values and priorities of society. Most research funding currently does not promote or require policy interaction. Universities must become better at offering **platforms for interaction** between researchers and decision-makers, particularly in local municipalities, where many decisions on infrastructures for energy, buildings, and mobility are made.

- Educate the next generation of leaders

A primary role of universities is to **educate the next generation of leaders**, so that they develop a good understanding of the dynamics of the global energy system. Student projects can be practically useful, for example in helping to convert the university campus to low carbon, and the same techniques can be applied in professional life. For example, in Geneva, Switzerland, new city development projects must include the exergy efficiency of the project¹³, enabling the city government to select building projects that truly maximize energy efficiency in the whole energy system. It was possible to make and use this city legislation because the city planners had been educated to understand and value the exergy idea. Another example is spin-off businesses created by university alumni that develop and sell alternative energy technologies.

¹² MIT (2007) The Future of Coal. Options for a Carbon-Constrained World. MIT Interdisciplinary Study. <http://web.mit.edu/coal/>
MIT (2003) The Future of Nuclear Power. MIT Interdisciplinary Study. <http://web.mit.edu/nuclearpower/>

¹³ Favrat, D., Marechal, F. & Epelly, O. (2008) The challenge of introducing an exergy indicator in a local law on energy. *Energy*, 33, 130-136.

The **ETH Energy Science Center** facilitates cross-departmental collaboration, exploits synergies for research and teaching, and strengthens research co-operation between its members and industrial and other outside partners. The ESC unites over 40 professorships from 11 departments within the ETH, and forms part of the Competence Centre for Energy and Mobility of the ETH Domain. In February 2008, the ESC published the *Energy Strategy for ETH Zurich*, with a vision of a transformation path for a sustainable energy system, introducing the strategic target of the 1-ton-CO₂-society.

Director: *Konstantinos Boulouchos*, ETH Zurich
Further information: <http://www.esc.ethz.ch/>

The **Japan Low Carbon Society Scenarios toward 2050** project arose out of an AGS project, and is coordinated by the Japanese National Institute for Environmental Studies in collaboration with the University of Tokyo and other partners. In February 2007, the scenario team for the project released a report *Japan Scenarios towards Low-Carbon Society (LCS)—Feasibility study for 70% CO₂ emission reduction by 2050 below 1990 level* (with a revised version in May 2008), demonstrating Japan's potential to reduce its CO₂ emissions by 70% (from the 1990 level) by 2050.

Contact: *Keisuke Hanaki*, The University of Tokyo
Further information: http://2050.nies.go.jp/project_e.html

The **MIT Energy Initiative (MITEI)**, established in November 2006, is an MIT-wide initiative designed to help transform the global energy system to meet the needs of the future and to help build a bridge to that future by improving today's energy systems. The MITEI program now includes research, education, campus energy management and outreach activities that cover all areas of energy supply and demand, security and environmental impact. Policy publications include *The Future of Coal* (2007) and *The Future of Nuclear Power* (2003).

Director: *Ernest J. Moniz*, MIT
Further information: <http://web.mit.edu/mitei/>

The **AGS Pathways to Sustainable European Energy Systems** project at Chalmers University of Technology is a five year AGS project with the overall aim to evaluate and propose robust pathways towards a sustainable energy system with respect to environmental, technical, economic and social issues. The focus is on the stationary energy system (power and heat) in the European setting. The project has substantial funding from Vattenfall AB, as well as funding from the Swedish Energy agency and the European Commission (in separate projects).

Director: *Filip Johnsson*, Chalmers University of Technology
Further information: <http://www.energy-pathways.org/>

The **EPFL Industrial Energy Systems Laboratory (LENI)** is a center of excellence in teaching and research related to thermodynamics and to sustainable engineering of energy systems (thermal or electro-chemical) and industrial processes. LENI develops thermodynamically-based generic methodologies for integrating and optimizing complex energy systems and networks, incorporating life cycle analysis (LCA) factors.

Director: *Daniel Favrat*, EPFL
Further information: <http://leniwww.epfl.ch/>

Keynote

Turbulence Ahead: Dynamics Shaping (and Occasionally Confounding) Local Energy and Climate Planning Efforts

Stephen Hammer, Columbia University



It is clear that, globally, **most energy consumption occurs in cities**¹⁴. In industrialized nations, urban life is actually slightly less energy-intensive than rural life, because of greater use of public transport and more use of synergies in energy supply through combined heating and power systems. In contrast, per capita energy demand of urban populations in China is nearly double that of rural populations; this is because migrants move into cities for economic reasons, and once they have acquired greater wealth, they consume more and adopt more energy-intensive lifestyles. The same

trend is seen in African cities. The massive urban population growth in Asia and Africa, coupled with more affluent urban lifestyles, has major implications for our global energy consumption.

In the face of these challenges—and in the absence of regulation from state and federal governments—**cities and local municipalities** are beginning to take action. However, as mayors begin to tackle issues of energy planning at the urban scale, their ability to implement sustainable energy strategies is restricted by limitations in their policy-making environment. Cities are subject to ground-rules set by regional or central government. For example, the New York City mayor, Michael Bloomberg, proposed a congestion-pricing scheme following the lead of London, Singapore, and Stockholm. However, under state laws, Bloomberg did not have the authority to implement the program. He had to ask permission from the state legislature, which, for a variety of political reasons, refused to grant him these powers. In the end, the program was never implemented. In contrast, the mayor of London, Ken Livingstone, was specifically granted authority by the UK parliament to implement congestion-pricing in the late 1990s. Often, mayors cannot impose energy-efficiency requirements on products sold in their city or impose taxes on carbon-intensive energy sources without authority from state or federal government. In the case of the ambitious London Climate Change Action Plan¹⁵, Ken Livingstone demonstrated that the mayor only has the power to implement changes to achieve approximately 15% of the total carbon emission reductions that are in the plan. He needed action by central government, individuals, and businesses to achieve the rest of the targeted reductions.

City mayors have to rely heavily on advocacy if they are to be a leader in sustainability. A close look at planning or policy documents in Paris and New York City reveals that city-level officials rarely offer mandates. Instead, their statements are much softer, asking people to change habits and cooperate. Implementation of energy strategies means very little without **support from the public and business**. During the debate over the congestion-pricing scheme in New York City, a leading business group, The Partnership for New York City, wrote a

¹⁴ IEA WEO 2008, World Energy Outlook 2008, IEA Publications, Paris, ISBN 978 92 64 04560-6, <http://www.worldenergyoutlook.org/>

¹⁵ Greater London Authority (2007) Action Today to Protect Tomorrow—The Mayor's Climate Change Action Plan. Greater London Authority, London. www.london.gov.uk

report in support of congestion-pricing, pointing out that high-priced lawyers and Wall Street bankers stuck in traffic jams are unproductive, and the city could realize significant economic benefit from higher productivity, and subsequently increased taxes on higher income levels. Mayor Bloomberg happily embraced this report and received the support of the business community in implementing a congestion-pricing scheme. In a joint study with researchers from Yale and Columbia Universities, 66% of New York City residents indicated they were prepared to pay some increased costs for the implementation of local policies for energy efficiency and renewables despite the personal economic implications. With supportive public opinion data, mayors can offset power limitations in political disputes.

It is a huge challenge for a mayor to implement sustainable strategies in an unpredictable marketplace.

Cities are subject to the influence of the **changing market**. For instance, electric vehicles could make a big contribution to reducing transport-related greenhouse gas emissions and overall transport-related energy consumption. However, the emission-reduction impact of electric vehicles depends on when and where the vehicles are charged: if the vehicles are charged at peak demand periods during the day, or if the electricity is used to charge the vehicles comes from coal, the total emissions could be higher than from conventional cars. Electric transportation also has significant benefits for quality of life in cities, reducing air pollution and congestion. Some fear that electric car owners may then feel less compelled to ride a bike or take a bus in downtown areas, creating more traffic and contradicting the Mayor's efforts to reduce traffic congestion.

Urban planning must be designed to anticipate technological developments. Large venture capital firms in the US are investing in advanced green technologies (for example, bio-diesel, solar thermal, and fuel cells), based on the projection that consumer demand will increase. However, this is dependant

on policies being implemented by local and regional governments. The green building guidelines imposed within the Battery Park City Authority district in New York City require developers to include **forward-thinking design** in their plans. For example, developers must allow space for the installation of fuel-cells at some time in the future, even if these technologies are currently not available. There are many other strategies to impose better planning. Frequently, air conditioning appliances are scattered over roof spaces, preventing installation of photovoltaic panels. A simple regulation could require consolidation of these appliances on one area of the roof, to leave space for immediate or future installation of renewable energy technologies. Land-use laws could include regulations to protect the solar access space on and around buildings.

There are many areas for university involvement in addressing policy questions and supporting policy-makers in their efforts to develop sustainability strategies. For example, in the energy sector a major concern is the **threat to coastal power stations** around our cities from increasing storm surges caused by sea-level rise. Many of these power plants are at risk of flooding and damage. Power station operators are not clear what the risks, probabilities, and responsible actions are. They need to know how or when to invest in their utilities to prevent disaster. Universities can provide information that helps operators understand the risks and how to make investment decisions.

Another role for universities is research into the relationship between **energy market structure and regulatory practices**. There is almost no information concerning the effects of market restructuring on local sustainability efforts. Although rule changes have opened the market for cleaner technologies to compete with fossil fuels technologies, it is not clear whether this will make sustainable urban planning more or less difficult to implement. It is also not clear whether this competition has led to a reduction in prices for cleaner technologies. Currently, the incumbent, fossil fuel-based technologies are often more economically competitive, making it hard for new, cleaner technologies to become established. This research has obvious policy implications at the local, state, and central government level.

The fundamental question about utility ownership must also be revisited. Are **privately- or publicly-owned utilities** better able to plan for, adapt to, or mitigate emissions in the age of climate change? Universities should conduct research into whether the requirement of maximizing shareholder return inhibits investor-owned utilities from making progress in sustainable urban development.

In dealing with politics, real estate developers and the entrenched energy interests tend to face the future with a 'business as usual' attitude. It is necessary that someone brings knowledge to the table and disrupts these attitudes. While policy makers are not willing or able to question these practices for political reasons, universities can use knowledge and science to raise questions about market structures and technologies.

Finally, it is critical that we question policy complexity: are we going about planning in completely the

wrong way? PlaNYC, New York City's new long-term growth and sustainability plan, has 127 different initiatives and includes development of new oversight bodies and close monitoring by regulatory agencies, which will cost people, time, and taxpayer dollars. This is a common situation in many other cities worldwide. Despite good intentions and hard work, the benefits may be smaller than anticipated.

Delivery of urban sustainability is a huge task, but it is a challenge we cannot ignore. Whilst the public awareness of climate change and the need for urban sustainability is a cause for optimism, we are now faced with the problem of determining what is possible from a policy perspective. Now that many technologies and methods capable of mitigating climate change and implementing sustainability have been well studied, we must turn our attention to how they can be implemented. From a policy perspective, implementation of these technologies and methods remains a huge challenge.

Panel

Pro-Poor Urban Futures in Developing Countries

Achieving the Millenium Development Goals will depend to a large extent on how well developing countries manage their cities. This panel, moderated by Barbara Becker, Managing Director of the North-South Centre of the ETH Zurich, discussed approaches to addressing urban poverty, such as offering alternative livelihood strategies, improving access to services, and social inclusion.

Social inclusion: residential institutions for street children in Brazil

Isa Maria Ferreira da Rosa Guar from the UNIBAN University in So Paulo, Brazil and **Anna Schmid** from the Zurich University of Applied Sciences in Dubendorf, Switzerland, presented their

research about the role of residential institutions in improving the lives of Brazilian street children. Because legal protection of children is only partially effective, more than 20,000 children in Brazil are raised in residential institutions. Although most of these children have families, they are often dispersed, impoverished, or otherwise incapable of providing care. Guar has found that consideration for children's families is important to the children's quality of life. Better training of local municipalities and more government support for families would improve the situation.

Some institutions do little to improve the children's state of social exclusion. Typically, the children are expected to submit to a dominant figure, being routinely punished or treated as souls to be saved. However, other institutions are more inclusion-oriented, such as the "Chacara dos Meninos de Quatro Pinheiros," a home to 80 former street boys near Curitiba, Brazil. Schmid found that the goals and design of the Chacara are inseparably linked with the basic concept of social inclusion, and concluded that this linkage is important for the development of the children and the success of the institution.

Innovative urban planning for sustainable and inclusive communities

Andrea Catenazzi from the National University of General Sarmiento, Argentina and **Adriana Rabinovich** from the EPF Lausanne, Switzerland study complex decision-making processes in innovative urban planning. Although the label ‘innovative’ is widely used, Rabinovich suggests that true innovation involves making links between factors that are traditionally considered separately, such as planning and implementation, or technical and political interests, or public and private sectors. Any decision-making process in urban planning is, above all, a value-based decision. Therefore the decision-making process must be able to accommodate and reconcile the values of many stakeholders.

Rabinovich and Catenazzi investigated three projects—in Buenos Aires, Havana, and Bangkok—that were intended to rehabilitate urban areas. All projects were labeled as ‘sustainable’ and had the goals of preserving heritage values, improving economic opportunities, and promoting access to housing for the lower-income population. Rabinovich and Catenazzi found considerable opportunities for innovation in urban planning in areas with heritage value, and are developing recommendations for replicating these processes in different contexts and integrating urban planning into national and international policies.

Urban agriculture as an alternative livelihood strategy

Ouola Traore from the Burkina Faso National Research Institute (INERA) described urban agriculture in the two largest cities of Burkina Faso, Ouagadougou and Bobo-Dioulasso, home to more than 15% of the nation’s 13 million residents and 60% of its urban population. Agricultural production is the sole source of monetary income for many low-income households in urban and peri-urban zones, and is practiced in available spaces between dwellings. Products include vegetables, arable crops and fruit, as well as animal products, and these contribute significantly to reducing malnutrition and urban poverty. Because of the importance of these products in Ouagadougou, a market was established, creating jobs primarily for poor women,

who can earn between 400 and 900 Euros per year from the market.

Many factors limit the development of urban agriculture, such as declining rainfall, competition from commercial production, inadequate equipment, lack of access to credit, lack of applicable laws, and lack of land tenure for women. Traore suggests several ways in which urban agriculture could be made more sustainable. These include: training for and organization of farmers, allocation of land for urban agriculture, implementation of land tenure programs, improved access to credit, and use of technologies that recycle solid and liquid urban waste in crop production.

Uses of wastewater and excreta in urban agriculture

Doulaye Koné from the Swiss Federal Institute of Aquatic Science and Technology (Eawag) discussed the economic potential of wastewater and excreta as reusable resources. Despite the millennium development goals, an increasing number of people have no access to proper sanitation. Many cities lack adequate sewerage systems and the majority of residents use latrines. New technologies that sustain environmental health in urban areas have to be developed, though it is unclear how this can best be done. While the technologies used in developed nations are not adaptable to most of these areas, many of the so-called low-cost solutions do not work.

Even low-tech sanitation systems require skilled operators, who are hard to find in developing regions. This leads to many families emptying latrines manually. Sanitation service-providers lack government assistance, so mechanically removed sewage is often emptied onto fields and used directly in agriculture. However, pathogens in waste represent a serious risk to public health, accounting for millions of deaths per year, many of them children. Many developing countries have plans for recycling wastewater and excreta for agricultural use, but technologies need to be developed that reduce pathogen contamination without losing valuable nutrients.

Panel

The Challenges for Institutions and Policy

The panel, moderated by **Harald Mieg** of the Institute for Environmental Decisions, ETH Zurich, and the Humboldt University, Berlin, discussed the institutional and policy changes needed in urban areas to achieve sustainability, including better understanding of available technologies, education for technology-users, improved coordination among various levels of government, and developing pro-poor business opportunities.

China's dramatic urbanization: training Chinese construction companies

Qiang Liu from Ocean University and Tsinghua University described some environmental institutions and policy developments in China. China's economy has grown to be the third largest in the world. However, this new wealth is very unevenly distributed, and dramatic urbanization together with migration from rural regions poses challenges as well as opportunities for sustainable development. Sustainability in China is understood as meaning social harmony and scientific development, and natural and manmade disasters—such as the earthquake in Sichuan—threaten to derail this. To strengthen environmental policies in China, more efficient and effective legal systems are required, providing greater accountability and transparency. Pilot projects and case studies that integrate environmental concerns into economic decisions must be implemented. Because of the huge building stock and the low standards to which buildings are currently built, even small improvements in China's buildings could contribute significantly to global sustainability. Great emphasis is currently given to high-tech sustainable buildings, but China also requires technical education in simple skills such as proper window construction, working with sustainable building materials, and small-scale photovoltaic panel installation.

Bottom-up entrepreneurship in the Philippines

Illac Diaz, from the Centro Migrante and My Shelter Foundation in the Philippines, demonstrated the potential for business opportunities to improve the lives of the poor. Until recently, it took a maritime worker arriving in Manila about 10 months to find employment. Much of this delay was due to inadequate contact between employment agencies and workers. Diaz established a housing program for maritime workers that addressed many of the social, environmental, and economic problems caused by this migration of labor. The shelters were built in a slum area where construction was economically viable. Existing buildings in the area were upgraded and the water supply was improved through rainwater collection and innovative technologies. These initiatives have helped the maritime workers to develop a sustainable social network, emphasizing responsibility and cooperation. Furthermore, by creating this housing system and grouping maritime workers by employment, the time they need to find work has been reduced to two months or less. From this and other projects, Diaz has discovered that even in impoverished regions there are business opportunities that can contribute significantly to sustainability.

Investing in building technologies for the future

Helmut Macht, the Chief Technology Officer of the Building Technologies Division of Siemens Industry Sector presented a technological perspective on challenges for institutions and policies. To achieve sustainability, cities must simultaneously ensure limited environmental impact, sustainable infrastructure development, and the health, safety and security of residents. Whilst established cities in developed countries must focus on maintaining quality of life whilst attracting industry and business, cities in developing countries must provide sufficient housing and services for a rapidly increasing population. Cities will have to invest increasingly in innovative solutions. Many products and services are already available for all types of cities, including building materials, heating and cooling systems, and energy efficient appliances. There are also business solutions to support sustainable development, such as efficiency consulting, energy monitoring and management, and investment services.

The discussion considered the following questions:

What education and training is needed so that more sustainable technologies get used?

Macht insisted that many important technologies are not complicated and builders require little training to properly install insulation or energy-efficient lighting. Liu pointed out that students increasingly demand sustainable projects and technologies in their professional education, thereby developing the education level to match technologies and encouraging broader implementation. Institutions and policy-makers need to understand how much can be achieved with current technology. This must be coupled with improved collaboration with stakeholders. How do we ensure that there are opportunities and education strategies for the whole range of skill sets for simple to high tech technologies?

How can policy contribute most effectively to promoting change?

Stephen Hammer from Columbia University emphasized the idea of joined-up-thinking—to develop integrated policies you need to break down the barriers between traditionally distinct divisions within city governments, which both forces and empowers the different parts to work together. Macht believes that to achieve progress, policy makers, investors, and industry must be brought together in coordinated measures. Hammer and Macht described how performance contracting public-private partnerships between government and private companies can create guaranteed markets for technologies while minimizing the necessary upfront investments. For example, a housing corporation makes a contract with Siemens for 12 years—during which the housing achieves the guaranteed energy saving level, whilst Siemens gets back its investment and some profit. Companies like Siemens seeing huge investment opportunities in emerging economies—but can they force entrenched local players to change?

What space for entrepreneurship and investment in low tech solutions?

Illac Diaz asked us to think about low tech high impact for the 3 billion world's poor. Entrepreneurs should view the sustainability challenge as a business opportunity, in which they can achieve financial success whilst creating more sustainable solutions. Integrated solutions build reuse, jobs, health care, and other benefits into the program. Qiang Liu argued that appropriate technologies and local solutions use local materials and local skills. This needs to be based on local innovation, not just on taking over technologies from other countries. Imported technologies benefit the richer communities in developing countries and do not touch the poor.



Panel

Transforming the Building Stock for Sustainability

How can we manage our existing building stock to dramatically reduce energy and resource use, in time and at scale? This question was posed to panelists in a discussion moderated by **Peter Richner** of the Swiss Federal Institute for Materials Science and Technology (Empa).

Drivers of change towards sustainable buildings in Japan

Ryozo Ooka from the University of Tokyo described the concepts and ideas for changing the building stock in Japan. He focused on broad drivers that encourage change in the market, with respect to both renovation and new construction. The four pillars driving the change are certification, regulation, economics, and education. Certification, through rating systems, like LEED in the US and CASBEE in Japan, provides confirmation that proper methods are implemented. Regulation ensures that people meet minimum requirements and are encouraged to achieve higher certification goals. Economics is best used to create financial incentives, encouraging developers and builders to build intelligently. Finally, technical and rational education of industry about the methods and benefits of making the built environment more sustainable is critical to the success of the other three pillars.

Integrated design for environmental, economical, healthy, comfortable and attractive buildings

China constructs 10 million new residences every year and builds as much commercial space as the rest of the world combined. For this reason, **Leon Glicksman** of MIT emphasizes the importance of solutions that can be rapidly deployed, with maximal impact. In his presentation, Glicksman highlighted the goals of creating sustainable buildings, arguing

that we cannot only address the environmental aspects, but must also consider economics, health, comfort, and aesthetics. This is a difficult task considering the attitude of the building industry and the general lack of public education about sustainable buildings. Achieving the goal of sustainable buildings will take time and no single “silver bullet” technology will bring us to this goal. In general, integrated design tools that reach across disciplines and back to preliminary designs will be key to achieving the dramatic improvements needed in the built environment. Glicksman presented some specific technological options that could easily be implemented, such as smart envelopes and daylight-use improvements. Finally, Glicksman impressed that monitoring of buildings after they are completed is necessary to provide validation of technologies for future application.

Upgrading and retrofitting for energy efficiency and changing lifestyles

Also focusing on technological upgrades for retrofitting buildings, **Carl-Erik Hagentoft** from Chalmers University of Technology presented projects taking place in Sweden, including upgrading of the large stock of houses built in the 1960s and 1970s. Because buildings have a long lifetime, ‘improvements’ in technology can sometimes cause unforeseen problems at a later stage. However, Hagentoft argues that current investments in building upgrades are tested and proven, and easily pay back initial investments with energy savings over the lifetime of the building. Furthermore, new technologies are available that make buildings more comfortable, attractive, and energy efficient. Hagentoft is optimistic about the potential of new technologies to have a large impact. He believes that the path to sustainable buildings will be influenced by increasing the demand for quality of life, inspiring new possibilities for the built environment, and stimulating new and unexplored technologies to provide more sustainable solutions.

Transforming the building stock to zero carbon by 2060

According to **Hansjürg Leibundgut** of the ETH Zurich, we have the potential to transform the building stock to zero carbon by 2060, cutting out the use

of fossil fuels completely. Energy in the environment, such as geothermal heat from the ground or solar and wind generated electricity, is abundant and available for consumption, we only have to implement the tools and technology to capture it. Using the concept of exergy, we can match low-quality energy from the ground (i.e. a heat source that has only a low temperature difference to the heat sink) to the low-temperature difference heating and cooling we need to create comfortable buildings. At the same time, we can make abundant solar and wind energy available by transporting it from places

where it is most abundant and economically viable to the places of high-demand. Leibundgut suggests that each building should be considered an individual with needs that can be optimized through appropriate sources of exergy and through extracting available energy from the environment. Each building can be connected and matched to its environment by selecting the appropriate construction elements for its specific situation. By integrating the various available technologies, any building can be designed to limit CO₂ emissions to less than 1 ton per person per year.

Panel

Urban Futures: Happiness, Mobility and Society

The transport sector accounts for over one-third of CO₂ emissions in industrialized countries, and is the fastest growing source: without significant technology change, transport-related emissions could triple or quadruple between 2005 and 2050. **Can we continue to increase travel and transport, build more transport infrastructure, increase vehicle fleets, and still achieve global sustainability?** This panel, moderated by **Kay Axhausen** of the ETH Network City and Landscape, brought together different disciplinary viewpoints to discuss the role of mobility in society, and its implications for global sustainability.

Andreas Schaefer from Cambridge University and colleagues from MIT have shown that in all parts of the world over the last fifty years, the average income (as GDP per capita) and how much people travel (in kilometers per capita) are strongly linked¹⁶. The actual amount of time people spend travelling, however, is surprisingly similar, despite large differences in income and culture. **This indicates that as people get richer, they travel**

faster and further, but on average they spend the same amount of time travelling. With increasing average income, there is a shift from travel with low speed public transport, to travel mostly with automobiles, and then to high speed transportation by fast rail and aircraft. This is also reflected in the fact that, although transport technology in industrialized countries has greatly improved, the overall energy intensity of transport has remained constant, or even increased.

The climate impact of transport can be decreased by reducing the per-passenger kilometers travelled, the energy intensity of transport, the CO₂ emissions per unit of energy used in transport, or by reducing all of these factors. Technologies are already available to **reduce the energy intensity of cars and aircraft by 30-50%**, without making any significant undesirable trade-offs in services; however, to implement these technologies depends on consumer acceptance as well as the readiness of automobile and aircraft industries to take the associated economic risk. Such technology change can be promoted by regulatory measures, e.g. to limit permitted emissions per kilometer or to mandate more efficient technology and fuel composition. However, reduced energy intensity also reduces the marginal cost of kilometers travelled, and any gains would almost certainly be lost by people increasing their travel. In contrast, higher fuel costs (e.g. through a CO₂ tax) would reduce all three components of transport impact: by increasing the cost of travel and changing the relative price of fuels to favor low-carbon fuels. **Fuel price policies can therefore**

¹⁶ Schäfer, A., Heywood, J.B., Jacoby, H.D. & Waitz, I.A. (2009) Transportation in a Climate-Constrained World. The MIT Press, Cambridge, USA.

decrease travel demand; however, Andreas Schaeffer argues that these gains would soon be matched by income growth, and that transportation demand is likely to continue to grow, even in a climate-constrained world.

So why do people continue to travel? Commuting often involves costs such as lowered frustration tolerance, bad moods, and negative health-effects, which individuals can avoid through their choice of home or work place. **Thomas Rutherford** from the ETH Zurich models people's choices based on their observed behavior. He analyses how people's choices about where they decide to live in relation to their workplace are based on a range of factors in addition to the commuting distance. It can be assumed that people make decisions about their mobility based on a trade-off between these factors.

Alois Stutzer from the University of Basel and **Bruno Frey** from the University of Zurich have been interested in whether people optimize their well-being through gains in other domains of their life

that compensate for the bad aspects of commuting¹⁷. They examined a socio-economic data set from Germany that included information on people's commuting time and their reported subjective life satisfaction. They found that overall life satisfaction decreased with increased commuting time, and that this could not be connected to any other factors in the data, such as increased satisfaction in other domains of life or spouse satisfaction¹⁸. **Stutzer and Frey conclude that people are bad at predicting trade-offs in their own well-being in significantly different aspects of their lives. People are especially bad at trading off social aspects (such as non-work time) versus material aspects.** People therefore underestimate how much they will adapt to increased material well-being, and overestimate their capacity to adapt to the unpleasant side of commuting. If people do not optimize their overall well-being in the choices they make about their mobility, models of people's mobility behavior based on the assumption of optimization may come out with the wrong predictions.

The following points arose in the discussion:

Do policies actually reduce traffic?

Travel creates social and economic benefits for society as trade is increased, and people specialize their work and carry out leisure activities, and it creates costs through traffic congestion, pollution, and other negative externalities. A person's decision to drive a certain route affects how well other people in the city can get to work on the same roads. The usual policy solution is to change relative prices through taxes or subsidies to try to account for the externalities. Two positive examples are Singapore's congestion charging and the Swiss heavy vehicle fee¹⁹. Singapore's congestion charging prices are actually high enough to reduce demand, and the city government is adjusting its prices on a quarterly basis according to measured congestion on different routes, which enables real control. The Swiss heavy vehicle fee has led to a significant increase in efficiency of trucks and better organization of materials-movement and transport routes.

Can we maintain economic productivity in industrial countries without increasing mobility? Or can we maintain growth in mobility whilst at the same time avoiding the negative costs through improved technology?

Economic growth is closely linked to improvements in transport systems and increasing mobility of people and goods, and industrialized countries heavily subsidize both public and private transport. Global companies have a global market, and their employees, goods, and raw materials have a global radius of movement. Should we continue to improve transport infrastructure to enable faster and further travel, or should we deliberately freeze any growth in transport networks or restrict access to high speed transport? This would constrain the local economy and restrict economic growth. On the other hand, without significant investments and technology improvements, transport networks in Europe are reaching the limits of their capacities.

¹⁷ Stutzer, A. & Frey, B.S. (2008) Stress that Doesn't Pay: The Commuting Paradox. *Scandinavian Journal of Economics*, 110, 339-366.

¹⁸ by multiple regression with all likely explanatory factors.

¹⁹ Schweizerische Leistungsabhängige Schwerverkehrsabgabe LSWA



Keynote

Global Change in the Urban Century

Nancy Grimm, Arizona State University



The global view of lights at night makes it obvious that cities are expansive ecosystems that demand our attention. As a result, the field of urban ecology is gaining recognition as a legitimate and important science. Urban ecology investigates how urban socio-ecological systems drive and respond to environmental change at all scales. Environmental changes brought about by humanity can be sorted into five major categories: land use and cover change, altered biogeochemical cycles, loss of biodiversity, climate change, and altered hydrosystems. Once the patterns of local, regional, and global drivers and responders have been established, changes can be made in socio-ecological systems to lessen their effects as drivers of environmental change and reduce the impact of environmental change on their inhabitants and ecosystems²⁰.

For instance, if cities turn out to be drivers of global environmental changes, what alterations can be

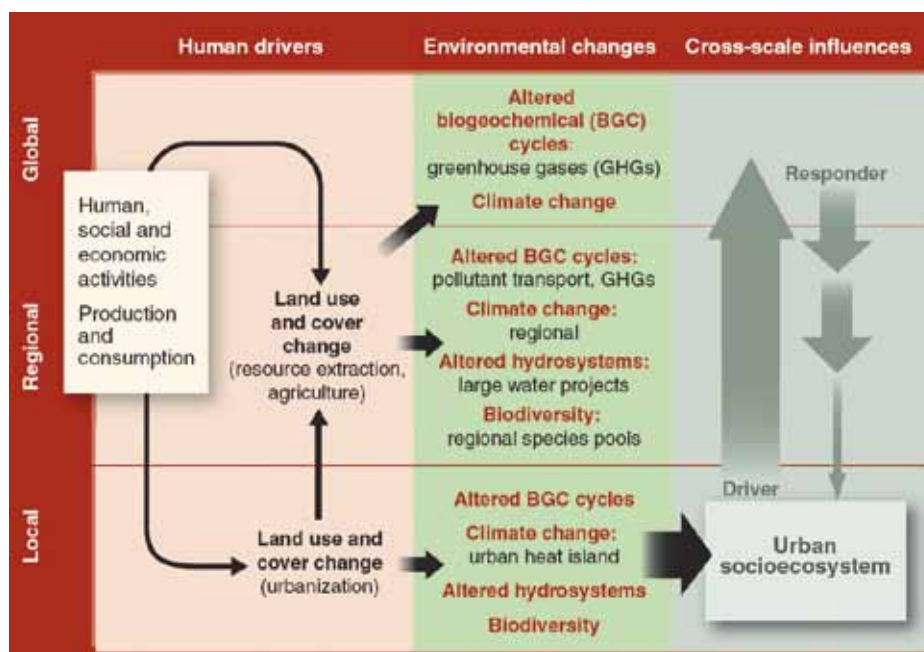
made in the socio-ecological system to mitigate these impacts? Urban ecology must be incorporated into sustainable development of urban areas because any solution not based on ecological principles will not be sustainable.

Land use and cover change. Although the surface area of cities accounts for only 2-4% of the earth's land surface, their impacts are far reaching. Compared to rural regions, cities produce much more waste and appropriate huge amounts of resources, such as water, food, fuels, and other materials. The majority of global carbon dioxide emissions, water appropriation, and wood production are attributed to cities. Therefore, while the area occupied by a city may not be large, the habitat loss associated with the food, water, and materials necessary to support a city is massive. One common concept for considering this impact is the ecological footprint, which is the productive land area required to supply all resources and assimilate all waste of a population. Although this concept has limitations, it is a wonderful tool for considering the impact of populations on natural ecosystems. Current calculations of the ecological footprint of the global community exceed the available land area of earth. The US leads in both per capita ecological footprint and total ecological footprint. The ecological footprint for carbon assimilation within the 20 largest cities in the US vastly exceeds the land area of the US. As economic growth, as well as population growth, continues, the global footprint will certainly increase.

The old formulation for calculating the ecological footprint of a city ($I=PAT$) considered size, affluence, and technology. However, ecological and geophysical locations of the city can have a significant effect on ecological footprint. For example, the compact versus sprawling urban form influences the ecological footprint. It is important to understand where the city is located geographically and what type of environment it is embedded in: cities built in arid regions have a very different resource demand than cities in less water-stressed regions.

At all scales, land use and cover change are the main drivers of environmental change. At the local and regional scale, land changes across the globe commonly lead to loss of wetlands in coastal areas, fragmented forests associated with urbanization and agriculture, and alteration of hydrosystems (rivers and lakes) resulting from demand-increase in arid

²⁰ Grimm et al. (2008) Global change and the ecology of cities. *Science* 319, 756-760.



The urban socio-ecosystem drives environmental change at the global scale, but also responds to environmental change at the local scale.

areas succumbing to urbanization. Landscape alteration and management resulting in homogenization of urban land cover is also seen at the local and regional scales. Around the globe, urban parks are remarkably similar to one another, regardless of climate. The fact that plant communities in urban settings have a higher evenness than the surrounding natural landscape is most likely explained by a tendency to plant landscapes evenly²¹.

Altered biogeochemical cycles. Humans are fundamentally changing biogeochemical cycles, partly as a result of the characteristics of urban metabolism and material imports. How and to what extent ecosystems are affected by waste from a city depends on the vectors, such as air, water, and organisms, transporting the materials outside the city. In Phoenix, a mass balance of nitrogen shows that inputs into the city exceed, by 7 or 8 fold, inputs into the surrounding desert. This discrepancy is mostly the result of fertilizers, food, and fuel imported by humans, as well as an inadvertent addition, accounting for about 30% of nitrogen input into the urban ecosystem, comes from conversion of nitrogen gas into oxidized nitrogen compounds, which are then deposited in the environment. As a

consequence, the urban nitrogen balance is grossly out of balance with the surrounding ecosystem.

Modeling studies show that nitrogen deposition in the Phoenix region occurs along a gradient related wind direction, but water is also an important vector. The old adage “the solution to pollution is dilution,” is constantly challenged by urbanization along coasts or rivers. Algal blooms, resulting from high nitrogen deposition in water bodies around the globe, lead to dead zones in areas of high nitrogen concentration such as the Gulf of Mexico.

Climate change. The phrase global warming is a misnomer, because many aspects of the climate are changing: extreme events, storm frequency, higher rainfall events, and drought. Global urbanization is a major driver of these changes, because most of the increase in atmospheric carbon dioxide can be attributed to cities. However, cities react more to changes in the local environment, such as the urban heat island, than to global-scale climate change.

Because it is important to prepare for the changes imposed by climate change, we should evaluate how varying patterns of urbanization interact with environmental gradients, with respect to climate change, and how they affect ecosystems and the services they provide. For example, superimposing

²¹ Walker et al. (2009) Effects of urbanization on plant species diversity in central Arizona. *Frontiers in Ecology and the Environment* 7, 465-470.

the spread of US suburbs on existing climate maps can help determine how cities will be affected by and respond to predicted climate change, and what effects this will have on urban ecosystems. This is particularly critical in areas susceptible to sea-level rise, hurricanes, drought, and inland flooding, especially because rapid growth is often occurring in places that are the most vulnerable. For example, in the western US there is an impending danger of extreme water shortages, partially resulting from the massive population growth. Meanwhile, despite climate-induced changes in river flow, transfer of water from agriculture to urban-uses continues in this region to support the population growth.

Altered hydrosystems. To provide water resources and manage storm water, humans have dramatically altered many hydrosystems at local and regional scales. As a result, streams and waterways are buried, channeled, or paved over, disrupting the natural connectivity of these systems and limiting their capacity to provide ecosystem services, such as filtration. For example, canals supplying water for agricultural and urban needs have essentially severed the connectivity of water systems within the Salt River Basin in central Arizona, which has affected ecosystem function within the basin. In addition to the increased channelization, an estimated 600 to 1000 artificial lakes have been built in the Phoenix metro area, where no natural lakes exist. Because artificially constructed hydrosystems are quickly replacing natural aquatic ecosystems, it is necessary to improve the delivery of ecosystem services, incorporating management, restoration, and design, into these systems.

Originally an ephemeral stream surrounded by farm fields, the Indian Bend Wash in Phoenix acted as a functional riparian area. However, over time, this stream bed was surrounded by development, and eventually a wholly artificial floodway of collection ponds was established in its place. The nitrogen budget of the current floodway shows that inputs and outputs (as denitrification) of this system are reasonably balanced, and this style of floodplain can handle an increase in nitrogen inputs. If fertilizer was not added to the grass around this floodplain, it could be used as a nitrogen-sink in the urban ecosystem.

Altered biodiversity. In general, biodiversity declines as a result of urbanization. However, cities

present intense selective pressure on organisms, which in some cases leads to an increase in biodiversity. In addition, humans intentionally manipulate biodiversity by planting exotic plants and placing selective pressures on insects. In his book, *Win-Win Ecology*, Mike Rosenzweig embraces the existence of humans by accepting that we live everywhere and assuming that we want to live in concert with other organisms. His concept of “win-win ecology” suggests that humans must seek out solutions to biodiversity loss through the idea not of preserving, but of reconciling our relationship with nature.

In conclusion, solutions exist that address the five categories of environmental change considered here. By designing compact, optimized cities, and consuming lower on food chain, humans can reduce demand on external resources, thereby reducing land use and cover change impacts of cities. Alteration of biogeochemical cycles can be abated through improved recycling of materials (industrial symbiosis), management of fertilizers, and development of new waste technologies. Adaptation of responsible habits and consideration of ecological factors can be implemented to mitigate cities’ effects on climate

Humans are fundamentally changing biogeochemical cycles.

change. Additionally, we have to realize that we may have to avoid those areas where impacts will be too great, such as low-lying coastal areas. Placing values on ecosystem services provided by hydrosystems, and implementing new technologies and ecological design for water distribution are critical steps in mitigating negative impacts from altered hydrosystems. Finally, we must consider biota in concert with and not opposed to humans, by establishing bio-reserves and open spaces in urban areas.

Cities, already responsible for environmental changes on all scales, are rapidly growing as we enter the urban age. However, the response of cities does not align with the level at which they drive these changes. Determining and mitigating the impacts cities have on local, regional, and global environmental change is critical to achieving sustainable urban futures.



Panel

Urban Ecology and Environmental Impacts

Ensuring that urban areas develop sustainably requires a solid understanding of how they function as ecosystems at several spatial scales. The panel, moderated by Janet Hering, director of the Swiss Federal Institute of Aquatic Science and Technology (Eawag), discussed aspects of urban ecology and the environmental impacts of urbanization.

Valuing water systems as interfaced ecosystems and socio-technical landscapes

Greg Morrison of Chalmers University of Technology described an approach to planning and managing water systems based upon a linked analysis of the supporting ecosystem and the socio-technical system. The relative importance in the analysis of the two components depends upon whether the system is evolving gradually or is subject to radical transformation. Slow evolution leads to greater emphasis on the ecosystem elements, as seen in the Mellby River project in Sweden. In contrast, the West Corridor project in Brisbane, Australia is an example of radical change, and the analysis mainly focuses on socio-technical aspects. In order to link ecosystem and socio-technical systems, it is critical to place values—either monetary or non-monetary—on both tangible and less tangible elements, as has been done for Lake Mälaren in Sweden.

Designing urban environments for sustainability and resilience: landscape topology and water

Christopher Girot of the ETH Zurich showed how empirical research and teaching in landscape architecture can contribute to sound environmental design in metropolitan areas. The study area, Santa Gilla Lagoon in Sardinia, is an area of coastal wetland where environmental quality and resources have been grossly degraded. The government of Sardinia built a large industrial harbor in the lagoon

that has been underutilized. The current water systems are unnatural, with serious salinization and blocked channel systems. A mixed group of architecture, landscape architecture, and engineering students from the ETH Zurich and Italian universities developed a holistic concept for the lagoon area, reestablishing water filtration and improving the ecological aspects of the landscape. They presented a plan for sustainable growth through adaptive reuse of the existing infrastructure to public officials and the community. Although the Santa Gilla Lagoon project was only an exercise, it inspired the community—and disastrous flash floods in the area provided a stark reminder of current shortcomings.

Will Venice survive? On the challenge of sustainability

Andrea Rinaldo from the EPF Lausanne used the example of Venice to argue that the preservation of architectural beauty can be a powerful motivation for socio-economic development. The residents of Venice have long adapted to flooded streets and shops, but adaptation only works up to a point. Engineering of the built environment on a small scale can mitigate daily, weekly, and monthly events, but will not provide protection from extreme events. Rising sea levels show that current infrastructure protecting Venice is insufficient and unsustainable. To preserve the city it may be necessary to create new salt marshes in the Venice lagoon. Can the engineering and architectural measures needed to protect Venice for the future be justified? The lagoon of Venice has been continually modified since the 1300s. Without human intervention, it would have disappeared centuries ago. This emphasizes Rinaldo's belief that 'natural' is a relative term, depending on what timeframe you are comparing to, and it cannot be applied too stringently. Although there is a widespread distrust of engineering solutions, engineering is not necessarily bad for the environment. We should therefore not be afraid to engineer the lagoon of Venice in order to pass such a cultural heritage treasure to future generations.

Environmental sanitation systems for sustainable cities and human development

For **Roland Schertenleib**, a consultant and former board member of the Swiss Federal Institute of Aquatic Science and Technology, wastewater management may not be a glamorous field, but it is vital to human welfare. Environmental sanitation includes all interventions necessary to provide a clean environment and reduce risk of disease, including management of excreta, wastewater, solid waste, storm water drainage, and control of diseases. In developed nations, sanitation systems operate on assumptions that are not applicable in developing nations. For instance, our systems assume an abundance of water (we flush our toilets with potable water) and availability of skilled labor and cheap energy, both of which are difficult to find in many developing nations. For developing countries, sanitation systems must be simple to use and maintain, robust, inexpensive, and culturally acceptable. Schertenleib has helped to develop an approach, called household-centered-environmental sanitation (HCES), that places the household and neighborhood at the center of the planning. This approach emphasizes participation of all stakeholders in developing an integrated system and finds a solution at the simplest, decentralized level. Furthermore, with this approach, waste may also provide a resource, for example as fertilizer. To the criticism that sanitation is too expensive, Schertenleib responds: can we afford not to implement proper sanitation? Recent studies show that it not only brings social and environmental gains, but can also be economically beneficial.

Decentralized, closed-loop urban sanitation systems

Kensuke Fukushi, from the Integrated Research System for Sustainability Science and the University of Tokyo, introduced himself as a promoter of decentralized sanitation. Economic development in Asia is driven by manufacturing and service industries, rather than agriculture, and has driven rapid urbanization since the 1970s. However, infrastructure cannot always keep pace with migration. The increasing urban population seeks economic success and a more consumptive lifestyle, causing water management problems from increased domestic and commercial water use and wastewater production. Excess production of wastewater, beyond the system capacity, leads to runoff and increased pollutants in waterways. Asian cities are relying on centralized water treatment and waste management systems, which are energy-intensive and costly. Treating this water consumes 2% of Japan's electricity demand. Decentralized systems are advantageous because they require small investments and simplify reuse of treated water. However, these systems require sophisticated water treatment processes, need maintenance, and increase the energy consumption of the individual user. Wastewater recycling systems must be designed with the use of the water in mind, for example water for agriculture or for groundwater recharge requires different levels of purification, and the system does not need to be so energy intensive. Small decentralized systems can be powered by local energy sources such as solar panels or wind turbines.



Keynote

Open City: Designing Co-Existence

Kees Christiaanse,
Network City and Landscape, ETH Zurich



Sustainability is an inflated term. Sustainable technology is, for example, creating zero-energy buildings, using alternative energy sources. However, **social sustainability** is a more complicated concept that cannot be solved with engineering, but must be encouraged by design. For example, in 1965, the Meerpaal Building, a large public building designed to host meetings, markets, sports events, and concerts, among other events, was built in Drunten, Netherlands. This building was built without interior walls and was a manifestation of what the Dutch would call “the makeable society.” There could be a concert and a city council meeting occurring at the same time, but the concept was well accepted. It was also the only building large enough to host live television shows, creating a paradigm for a multi-cultural society, in which everyone could carry on jobs or activities without hindering others.

Architects cannot create **social cohesion** by design, but they can develop breeding grounds for socially responsible societies, where residents’ behaviors will lead to social sustainability. GWL-Terrein, a neighborhood in the Amsterdam designed in the early 1990’s, was the first ecological neighborhood in the Netherlands. The design includes many sustainable technologies but, more importantly, social cohesion was stimulated through urban and architectural designs. For instance, social infrastructure has been established in the old waterworks buildings, connecting modern with historic use. Also, most of the land is divided into private gardens, thereby augmenting residential commitment, providing socially secure conditions, and reducing the costs of maintaining public spaces. Furthermore, there is a maximum of 20 front doors per staircase, encouraging social interaction. And the ground-level spaces were designed as flexible spaces for small economic developments. Altogether, this design has reduced vandalism and promoted social cohesion, transforming the neighborhood into one where its residents are actively involved and engaged. Eleven years after inception, it has become the most socially sustainable neighborhood in the Netherlands.

We must differentiate between social sustainability and sustainable technologies.

On a larger scale, the term ‘**Open City**’ can be thought of less as a definition than as a quest for the urban ideal. This concept deserves attention because present-day methods of city planning and design contradict important principles of an open city. In many cities, districts are increasingly isolated from each other, connected by single-access transport systems, so that communication is stifled. This branching design is exactly what Christopher Alexander warned against in his book “The City is Not a Tree,” and we can see its effects on a spatial, social, and programmatic level. Many new neighborhoods are designed as isolated, gated communities, which neither adapt to, nor accommodate societal shifts.

In order to maintain the historical relationship between the transforming parts of a town and the residents, land must be used efficiently, based on high-density design. Density, in all aspects, contributes to sustainability, not only through efficiencies in energy use and transport, but also by stimulating social exchanges, creativity, and innovation.

In an open city, **public space** is a cohesive system, with a fine maze of connections amongst communities and organizations forming a network of open exchange. The London School of Economics, for example, is located in an old neighborhood of London where the university bought or rented spaces one-by-one, eventually forming a campus that is integrated into the neighborhood. This neighborhood has great variety in its architecture and spaces, mixing old and new buildings, creating a creative environment that is truly an open city. Originally, this part of London was a pedestrian zone in which all exchanges of goods and information occurred by foot, which limited the spatial range of these exchanges. This is no longer the case; today students still travel in a common open space, but they are connected through technologies, such as the internet and telephone, to many different virtual global spaces. The continued vitality of this area demonstrates that neighborhoods can adapt to and accommodate diverse societies.

Creating a predetermined urban design for a city will not transform a city. Instead, the current status of the city must be used as a starting point from which transformation begins. In this sense, **design is an open process**, without a predetermined end or goal, and must be constantly recalibrated to the changing society and urban conditions. An example is provided by the city of Perm, in Russia, for which my partners and I had the opportunity to develop a master plan. Perm, which was originally a mining town, later became one of the many Gulag cities where prisoners worked in military factories. Interestingly, this history also made the city wealthy and able to undertake such a project.

The initial status of the city varied by area. There was an attractive city center with mixed-use buildings of middle-European architecture, and other areas, developed during Soviet times, that were in need of redevelopment. As seen in other Russian cities, the planning concepts for Perm included massive modern buildings designed without regard

for local social and economic conditions. Furthermore, mansions for wealthy businessmen were beginning to fragment forest areas in the outskirts. However, although existing plans were wholly unsuitable for an open city, the city government had devised a clever aid to town planning: drawing and devising proposed developments on a SMART Board™, with various stakeholders being present to give input. My partners and I were able to extend this stakeholder management technique by bringing the SMART Board™ into the streets and involving the locals in the discussion of neighborhood development.

In the end, we were able to convince the Perm government to adopt a radical model for their city, in which existing built-up areas would be consolidated within a specific boundary, and all building outside that area would be forbidden. Prior to this plan, the opposite had been happening: despite the fact that 80% of the existing buildings in Perm needed to be rebuilt, new construction primarily occurred on the fringes of the city. According to the new open city plan, new buildings must be built within the current built-up area, and replace an existing, outdated building. Because the city had already completed a new ring road, this was incorporated into the model as a firm boundary beyond which building was strictly forbidden. The open city design also used the existence of natural features, such as canyons and streams, to shape open space within the city.

We have also been commissioned to design the master plan for East London following the 2012 Olympics, which offers an interesting example of how an inner-city area can be redeveloped. Originally an industrial area with mills and plants, this region is now derelict and in need of revitalization. By turning the gated community of the Olympics into an open city design, we plan to create socially sustainable activity. The extent of neighborhood enhancement will involve more capital investment for redevelopment after the Olympics than before, ultimately promoting adaptability and longevity, maximizing connections to neighboring areas, activating public areas with waterways, and encouraging diversity.

To encourage growth of a sustainable society, it is important to design mixed-use buildings with residences, offices, shopping, and restaurants. This

creates a transition between public and private uses and leads to active, attractive street-fronts. Mixed-use designs also make it easier to steer the economic health of neighborhoods and prevent the formation of bedroom communities. In our work, we use **simple rules, rather than rigid plans**, to help create a breeding ground for social development. For example, the ground floors must all be double ceiling-height to promote mixed-use. And buildings should have small plots, promoting a maximum number of plots and diversity in architecture. In this way, designs and plans allow flexible uses that can develop organically as a neighborhood grows.

It is also important that a project progresses through a process of simultaneity, what I call ‘simultaneous

chess.’ In conventional planning, individual elements of a plan are performed linearly: first an inventory and evaluation is conducted, then design principles are created, followed by a layout, incorporation of technical aspects, stakeholders, and client management, visualization, and finally, planning application and implementations. However, our group implements these steps simultaneously. During this process, we focus on socio-economic development, which gradually becomes a planning agency, referred to as a regeneration process, parallel to the physical development of the neighborhood. Furthermore, we encourage competition among planners, engineers, and architects to create plans that are highly varied, as opposed to the traditional form of neighborhood development.

Keynote

Vision for the Future of Cities in the Ecological Age

Peter Head, Director of ARUP



The **‘ecological age of humanity’** is a response to the extremely unsustainable conditions created during the industrial age. With current rates of consumption, the earth is, in effect, shrinking. For example, as population grows, the amount of land available to support societies shrinks: one hundred years ago there was an average of eight hectares per person while today there are only two hectares, and yet we continue to live as though nothing has changed. Although climate change is just one part of the crisis, it is a driver of many other problems, and its pace is accelerating. Unfortunately, most humans are in denial that this situation has come upon us, making the need for a transition to sustainable living increasingly urgent.

In a two-year research program, ARUP is evaluating the feasibility of an increasing population living sustainably on the planet. We attempt to answer the question, ‘Is there a model that will work with 9.5 billion people in 2050?’ We show how carbon

emissions can be reduced globally by 50%, if developed nations commit to an 80% reduction while developing nations reduce their emissions after 2030. Achieving this target demands a completely different way of living, in which people produce 1–2 tons of carbon per person per year, with an ecological footprint of 1.44 hectares per person. And the human development index must be aligned with the Millennium Development Goals. However, this target requires a drastic lifestyle change, even in European cities, and many technical adaptations, policies, and investments are needed to make the transition.

ARUP uses principles from the natural world in urban design, calling it **‘smart responsive simplicity’**, as described in the book ‘Biomimicry’ by Janine Beynus: 1) Use waste as a resource, 2) Diversify and cooperate, 3) Gather and use energy efficiently, 4) Optimize not maximize, 5) Use materials sparingly, 6) Clean-up, do not pollute, 7) Do not draw down resources, 8) Remain in balance with the biosphere, 9) Run on information, 10) Shop locally. ARUP has designed an integrated resource management model that takes traditional models of urban design from the perspective of water supply, transport, waste, energy, etc. and interconnects them.

Dongtan was an ARUP plan for a green-field site in China, designed as a collection of three villages housing approximately 50,000 inhabitants, with a density of about 100-130 people per hectare. The goal of running the city entirely on renewable resources has encouraged innovative designs at all levels of the development process. For example, green roofs cool the city and mitigate the urban heat island effect. The city plan has an innovative water management system, with canals and lakes that collect and recycle water. The transport system maximizes accessibility by integrating bike and pedestrian areas with public transport connections. All vehicles are fueled with electricity or fuel cells, and therefore buildings can be designed from a new perspective, with 70% less energy consumption than traditional buildings. The energy supply comes from a decentralized, combined heat and power system, with photovoltaic panels on all roofs, a large wind generation capacity, and energy from waste systems.

In cities in low- to middle-income countries, 60 to 80% of people live in uncontrolled, unmanaged slum conditions. The great challenge for these

regions is to **transition from the agricultural age to the ecological age** without following the model of industrial countries. This challenge will be exacerbated by impacts of climate change, poverty, and food price increases. Large numbers of poor people spend 70 to 80% of their income on food, and if food prices rise, the impact is great. To reverse this process it is critical that food production is integrated into urban living. From evidence-based research, ARUP has shown that urban and rural regions are not distinct, separate developments, but integrated systems, where resource flows must be considered in management.

City retrofitting is applicable at all levels of development and requires breaking dependency on current paradigms.

In a typical **informal settlement** in Africa, the most important developments are public water sources, sewage systems, drainage, and water treatment systems. By reducing the time required to collect water, this infrastructure allows more time for productive work. Pathways and roads can be upgraded to improve access to public areas and facilities. Public transport so that people can get to work in surrounding areas will attract small businesses. Finally, open space and energy efficient buildings can be developed. The first step is to ensure that people have land tenure, which is essential for job creation and stimulating the flow of micro-credits. Once people have access to credits, a proportion of these can be used for improving the ecological infrastructure within the community, driving development in an organic and socially sustainable way.

In North America and Europe, ARUP refers to **'city retrofitting'**—improving resource efficiency by changing the way cities are configured. Getting away from our societies' dependence upon fossil fuels has many implications. We no longer need to build buildings that resist the noise and pollution of gas and diesel vehicles. Roads can be redeveloped for use by buses, walkers, and cyclers. Green vehicle fleets can distribute freight within the city from consolidation centers. Achieving sufficient urban density is fundamental to lowering energy consumption and progressing to a new model of sustainable living. Energy from anaerobic digestion of organic wastes could account for 10 to 15% of our total energy consumption. Water capture and recycling of wastewater are also commonsense actions that are insufficiently used.

Leadership on many levels is essential: we need global leaders to set examples. China is determined to become a leader, not out of global responsibility, but rather out of need for self-preservation. While China has recognized the need to transition to renewable energy sources and design resource-efficient societies, it also recognizes the need to educate society to be ecologically aware.

We have to make the transition to living in harmony with the natural world very quickly. And because urbanization is occurring so rapidly, urban design and land use planning will be at the heart of our efforts to live sustainably.

Societies that make the transition swiftly will be the most stable by 2030.



Panel

Size, Shape, and Sustainability of Cities

Cities are complex systems that integrate a multitude of societal, economic, and environmental components. The panel, moderated by **Bernd Scholl** from the Network City and Landscape at the ETH Zurich, discussed how the complexity of cities can be harnessed to achieve goals of sustainability. In his opening remarks, Scholl highlighted how the spectrum of urban economic development globally poses big challenges for planners. Historically, population growth was solved by consuming more land; nowadays in western countries increasing of well-being often means larger housing units and increased land consumption even in regions where the population is shrinking; but this cannot continue. To halt urban expansion, we must find optimal city densities, applicable to diverse settlement patterns. While many regions have begun implementing regulation strategies that guide future spatial development, there is no single answer for all urban areas.

Urban-rural harmonization for more sustainable resource use in Japan

Kazuhiko Takeuchi, from the United Nations University and the University of Tokyo discussed how urban areas in Japan could be made more sustainable. Unlike many other Asian countries, where populations are rapidly expanding, Japan must cope with a declining population. Currently, Japan relies heavily on imports, while the population of traditional suppliers of food and timber in rural regions is aging and shrinking. This is clearly not sustainable. To establish a sustainable, self-sufficient society, Japan must revitalize its shrinking city-centers as economic hubs, while stabilizing the population of rural areas. Since 1960, Japan's self-sufficiency in food production has decreased from 80% to 40%, and today, Tokyo is only 1% self-sufficient in food production (on a calorie basis). A similar trend can be seen in self-sufficiency of timber. Promoting population growth in the rural, mountainous regions is

a great challenge, but will greatly improve Japan's self-sufficiency. Takeuchi believes that resource-recirculation schemes—at the local, regional, and national scale—will help revitalize the rural and small city areas. Decentralization of authority can improve the resource efficiency and ecology of Japanese cities. However, this decentralization effort must include an expansion of agricultural business concepts for rural regions, in addition to the revitalization of global business centers in cities. Finally, although Japan must struggle to maintain the vitality of its cities, the population decrease can be regarded as a merit, not a detriment. For example, only by population decrease will Japan achieve its goal of a 60% to 80% carbon emission reduction by 2050.

Tackling urban growth by learning from history

Bish Sanyal, of MIT, reminded the audience that in urban sciences we are not working from a blank slate: we can learn a lot from the history of urbanization and modernization. Following the end of colonization in Africa and Asia, rural populations were encouraged, and sometimes forced, to move into urban regions, to contribute to growing urban economies. This economic development was believed to go hand-in-hand with formation of western-style democracies, a notion that has been continuously challenged by dictatorships as well as the model of present-day China. By the 1970s, population growth that exceeded the capacity of cities led to huge informal settlements, which, from the perspective of the city, out-weighed the benefits of migrant populations. As a result, city officials unsuccessfully attempted to send the impoverished back to rural areas. However, migration continues because urban regions often offer more opportunity than rural regions. Therefore, the response by cities has been to create secondary cities that can absorb massive population growth. Sanyal suggests that this growth strategy is not effective because spatial policies are too weak to counteract market trends in labor, capital, and commodity between city and rural regions. To Sanyal, this is a lesson we should have already learned. He argues that given the immense populations living in informal peripheral settlements, we should focus academic research on upgrading living conditions and integrating these people into the formal economy.

Is the city computable? Modeling urban areas for better decision making

Darren Robinson of the EPF Lausanne showed how modeling resource flow in urban areas **enables evaluation of alternative planning scenarios**. The Sustainable Urban Neighborhood modeling tool (SUNtool) is an integrated, resource flow model simulating energy, water, and waste flows in a way that is sensitive to the urban microclimate, human behavior, and local synergetic exchanges. This model can be applied to either existing or proposed settlements. A number of variables are used to define a building or development, including heating and ventilation, window-area, as well as energy sources, location, and climate. Once a development

is defined in this way, the model can be used to simulate the performance of a group of buildings under various conditions and over different time periods. Ultimately, models can offer guidance about manipulating the urban microclimate, building design to minimize resource demand, land use changes, feasibility of decentralized resource management options, and targeting of programs for synergetic exchanges and renewable energy technologies. They are also useful tools for participatory planning. SUNtool has been very successful, and its successor, CitySim, is scheduled for release in 2009. According to Robinson the city is computable, though there are still significant challenges to achieving this in a comprehensive and efficient way.

Panel

Urban Futures: How AGS Universities are Tackling the Challenge

This panel presented examples of integrated research initiatives at AGS universities with the goal of achieving a sustainable urban future. Further examples of related research were presented in five AGS seminars organized during 2008 as part of the AGS Urban Futures initiative. Webcasts and reports of these seminars are available online at the AGS website (www.theags.org/urbanfutures).

The University of Tokyo – Sustainable City Regions in Asia

In many ways, Asia holds the key to global sustainability, with two-thirds of the world's population,

expanding mega-cities and urbanized regions, soaring energy demand in China and India, and adverse impacts on natural resources. At the same time, many people in Asia still live in rural areas and rely on agriculture, forestry, and fishery. A mosaic of urban-rural land uses is a common phenomenon in the fringe areas of large Asian cities. Although current city planning systems based on western models attempt to clearly separate urban from rural, increased urban-rural interactions and harmonization can be a way of establishing sustainable city regions in Asia.

Within the AGS, the University of Tokyo is focusing on the Asian region. The university has created the **Transdisciplinary Initiative for Global Sustainability** (TIGS) to integrate research and structure knowledge on the major sustainability challenges. TIGS initiates flagship projects, runs sustainability education programs, and develops vision proposals. TIGS has initiated **partnerships with Japanese and Asian universities** to try to help these universities contribute to solutions. In February 2009, this AGS regional network hosted an urban futures workshop to develop new concepts for sustainable city regions in Asia.

The sustainable city region concept is based on the thesis that increased urban-rural harmonization will lead to increased sustainability²². Key ideas include:

- **Creating ecological networks** to connect urban and rural areas and restore urban ecosystems.
- Reform **local and regional governance**, with emphasis on community-based initiatives using participatory approaches. Preserve the value of rural culture and lifestyles.
- **Bio-resource circulation** as a city model for small cities in rural regions. For example, strategies to promote local food production for local consumption and technologies for small cities to increase their use of bioenergy (such as wood residue fueled district heating systems or biogas from organic waste) will also stimulate the rural economy.

Chalmers University of Technology – Supporting Urban Innovations

Chalmers University of Technology is launching two new research initiatives intended to promote interdisciplinary research in addressing the challenge of urban futures.

The **Gothenburg Center of Excellence for Sustainable Urban Futures** (GotSUF) is a transdisciplinary platform that brings together researchers with the Gothenburg regional administration, industry groups, and the Gothenburg society as full partners. The platform will have four interdisciplinary research groups working on (1) management of urban complexity, (2) socio-economic and cultural adaptation and innovation, (3) urban governance, and (4) sustainable urban metabolism and land use. Through this project, the efforts of each group will be integrated with the others, leading to a fusion of knowledge. The **Chalmers Academy for the Built Environment** is a bottom-up collaboration between architects, civil engineers, and material scientists to design sustainable homes for tomorrow.

Universities must also educate students who can tackle the urban futures challenge with innovative solutions, which is the aim of the Chalmers Masters program **Design for Sustainable Development**. It aims to provide students with skills and methods for a holistic and systemic approach to design that supports sustainable development in diverse and dynamic contexts. As part of the Chalmers partnership with UN-Habitat²³, students participate in a reality study in Kisumu, Kenya, in which they share everyday life with Kenyan families, conduct a system analysis of their experiences, and design a practical project that is then implemented in the community.

MIT – Portugal – Urban metabolism – an integrated assessment model initiative

Urban metabolism is an **interdisciplinary effort** to characterize and account for all physical flows that support urban activities and result from—or are driven by—important socio-economic and biogeochemical processes. This requires **integrated assessment models** that link biogeochemical flows and processes with socio-economic processes in a dynamic environment (as opposed to models that track a single material). We need to understand the linkages between very unlike things—political dynamics, economics, social change, resource flows—and be aware of the scope of both the processes we are analyzing and the methodologies we are using. The “Resource efficient management and alternative planning: Lisbon” (ReMAP)²⁴ project of the urban metabolism component of the MIT-Portugal program tries to do this by combining two methodologies: material flow analysis²⁵ and system dynamics²⁶.

Material flow analysis models the mass balances between inflows, additions to stock, and outflows within the defined urban zone. By tracing these inputs, stocks, and outputs, we can identify stocks of materials that we could extract and reuse, determine how long materials stay in a city, and identify ways in which outputs could be reduced by recycling of materials within the city, creating closed material loop networks.

²² AGS TIGS / IR3S, UT Global Center of Excellence for Sustainable Urban Regeneration, and Udayana University, Bali (2009) The Urban Futures Initiative: International Workshop on Sustainable City Region. Proceedings of the International Workshop on Sustainable City Region, Bali, February 23-24, 2009.

²³ Chalmers UN-Habitat Partner University events. <http://www.chalmers.se/gmv/habitat-en/events>

²⁴ MIT-Portugal website. <http://www.mitportugal.org/ses/research.html>

²⁵ based on work by Paulo Ferrão, e.g. Material Flow Matrix.

²⁶ based on work by John E. Fernandez, e.g. unpublished work on New Orleans.

System dynamics reveals unintended consequences and confounding variables, and gets to the heart of the probable behavior of these complex systems, given the identified system attributes and predictors and their set of relationships. The flows of active inputs in the city can be allocated to defined socio-economic activities, which can then be characterized, modeled as a sub-system, and related to other sub-systems. For example, the system dynamics of the activity of providing food relates food production, distribution and consumption to socio-economic and structural factors in the city.

The project is focused on providing important insights into the behavior of cities for the purpose of advancing effective proposals towards a more humane and ecologically responsible urban future. Combining material flow analysis and system dynamics allows us to identify the opportunities as well as the pitfalls for urban policy-makers trying to reduce the resource consumption and emissions and improve the livability of their city.

ETH Zurich – Future Cities Laboratory

The Future Cities Laboratory program, put together by a large team of ETH faculty and international partners²⁷, aims to create an **integrated think tank to design and develop sustainable future cities**. This interdisciplinary integration is

embodied in a research matrix based on the stocks and flows model of urban metabolism as articulated by Rogers²⁸ and developed by Oswald and Baccini²⁹ at the ETH. The matrix is organized into seven streams—people, energy, water, materials, capital, space, and information. Each stream has a research project is situated on a scale from the small (buildings), to medium (urban design), to large (territorial planning). While some of the projects focus on a particular scale, others span the entire range. **Design research studios**—the S-Lab, M-Lab and L-Lab—for students and experts will bring together the different streams at each of the scales.

Underlying the whole project is a simulation platform on which the integrated research results can be visualized as feasible solutions. These interactive tools and spaces will also enable participatory interactions and synergies with research centers, the population, government agencies, city governments, and industry. The program will produce practical as well as theoretical results, combining intelligent building technologies, digital and high-precision construction methods, the science of new materials, and reuse of urban materials with design of low-emission buildings and cities, and design for longevity, security, and social sustainability.

²⁷ Gerhard Schmitt, Marc Angelil, et al. (2008) Future Cities Laboratory. Research proposal submitted to the National Research Foundation of Singapore.

²⁸ Richard Rogers (1997) *Cities for a Small Planet*. Faber & Faber, London.

²⁹ F. Oswald & P. Baccini (2003) *Netzstadt: Designing the Urban*. Birkhauser, Basel.

Impressions



From top left to bottom right: reception, Filip Johnsson, coffee break in the ETH main building, poster session, the energy panel, students from Kenya and Uganda at the poster session, Konstantinos Boulouchos, Ralph Eichler's opening address.

Contributors

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