LOCAL EXAMPLES, GLOBAL PERSPECTIVE: FROM THEORY TO PRACTICE IN DESIGNING, MEASURING AND BENCHMAR-KING CARBON-NEUTRAL ARCHITECTURE

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Figure 1. "The Anthropocene: Welcome to the Age of Modern Man, Low-Density Development, Island development in China. Source: http://www.bbc.com/future/story/20120209-welcome-to-the-age-of-modern-man, accessed 5/23/2012.

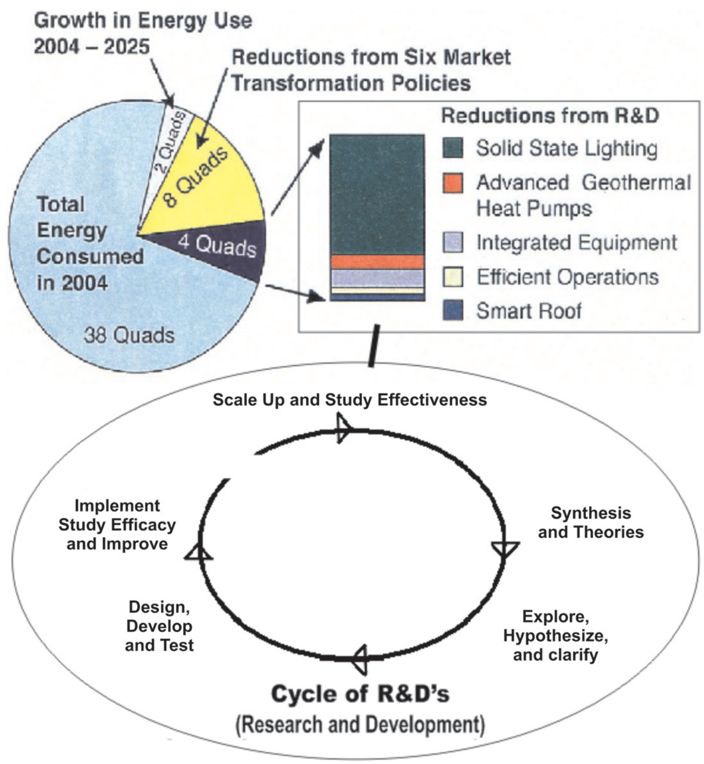

Figure 2. Growth in Building Energy Use 2004-2025 with Reductions through R&D's. Diagram: Author based on ISES 2012 Climate Change outlook, 2012

LOCAL ADAPTATION INCREASES ACCEPTANCE FOR GLOBAL BENCHMARKING

The debate surrounding rising greenhouse gases in the building sector centers on the premise by some researchers that climate change is not caused by emissions while others advocate for instant global action to reduce air and environmental pollution. However, even the latter group disagrees on timing, goals, and means. Despite all the disagreements, it is certain that any kind of climate change regulation would have deep implications for major business in different market economies and in particular for the growth in the building sector including Research and Development (R&D). In this sense the complex stakeholder structure in the building sector is one of the major elements inhibiting the opportunities of major market transfer with R&D's towards measureable sustainability in design, planning, and operation of buildings and cities (Fig. 2). Meanwhile the fragmented delivery process can be a challenge for combined policy instruments, mostly because of the different stake-holders that are regulated by different policies in diverse cultural and climatic settings across the globe. By the same token, an integrated construction and operation solution would pose a challenge because of the fragmented value chain in the building sector in different countries. The bigger question then is how to merge the collaborative efforts of all the different stakeholders in order to come up with a feasible solution for all the previous issues mentioned.

THE AMBITIOUS E.U. NET-ZERO-ENERGY BUILDING DIRECTIVE 2018-2020 AND THE U.S. CARBON NEUTRAL ARCHITECTURE AGENDA 2030

For decades, resource assessments and calculating GHG emissions for the international benchmarking of countries, cities, and buildings have been coordinated under the um-brella of the United Nations Framework Convention on Climate Change (Fig.3). The organization is also an international clearing house for data collaboration and coordination for building energy efficiency and carbon metric measuring.[1] This includes locally and regionally practice orientated sustainability rating tools such as: The ISO Sustainability in Building Construction, Life Cycle Assessment, and Building Energy Performance with 158 country members, UK BREEAM, DNGB in Germany, CSTB in France, CASBEE in Japan, Green Star in Australia,

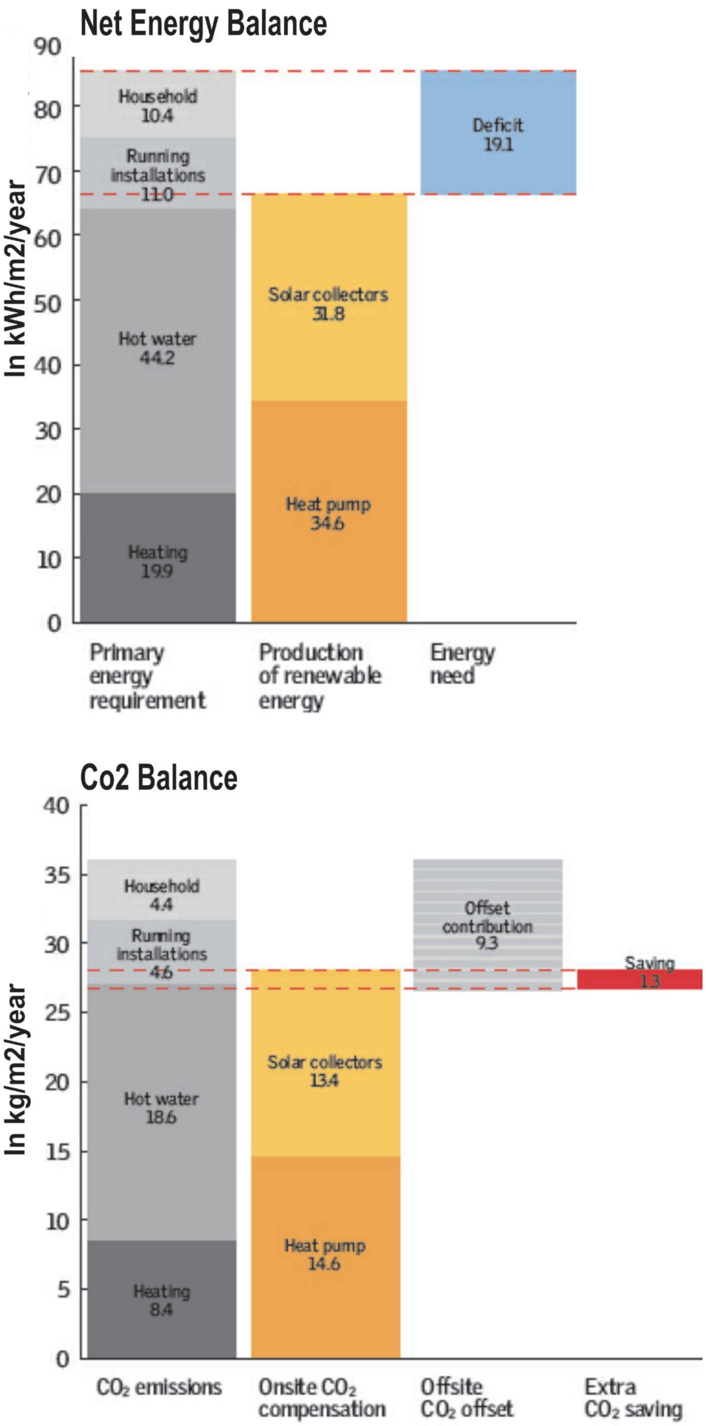

Figure 3. The CarbonLight Model Homes 2020' in Rothwell (Northamptonshire), 2009. Source: Velux DETAIL – Das Architekturportal, http://www.detail-online.com/architecture/topics/toward-co2-neutrality-018728.html , accessed on 5/23/2012.

Chinas Green Building Label, UEA in Dubai, and Energy Star or USGBC L.E.E.D. in the U.S., some of which are also united under the umbrella of the World-Green Building Council.

For example, the E.U. Directive on Energy Performance of Buildings (EPBD) has progressed to set mandatory goals to have all new 'public' buildings be 'nearly zero-energy-buildings' or nearly carbon-neutral by the end of 2018 and all 'private' buildings by the end of 2020. The nearly zero or very low amount of energy required should be covered to a very significant extent from renewable sources, including energy produced on-site or nearby.

Fig. 3 shows an example of an E.U.-Passive House 'Net-Energy-And-CO2-Balance' proce-dure in Rothweil, UK. In the United States the American Institute of Architects (AIA) has proposed the voluntary '2030 Challenge', which aims to achieve fossil fuel reduction for all new buildings by 90% in 2025, and carbon-neutrality by 2030.[2]

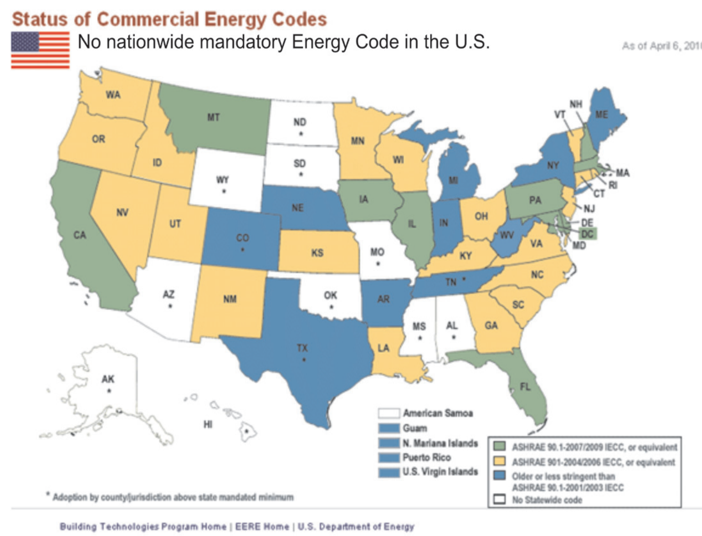

Figure 4. U.S. Department of Energy Web. The White Areas represent no mandatory commercial Energy Codes in certain U.S. states, 2012. www.energycodes.gov/states, accessed on 4/6/2012.

THE NEED FOR A WORLD WIDE COMMON METRIC LANGUAGE

The need for a world-wide common language and definition for sustainable building assess-ments is nevertheless urgent. Some countries have defined mandatory sustainable building ratings or energy saving ordinances based on a total life-cycle-approach through national rating systems and legislation, which are applicable to both retrofit and new construction. Most countries, even OECD (Organization for Economic Co-operation and Development) countries such as the United States do still not have such streamlined nationwide mandatory building energy saving references, codes, and educational training centers (Fig. 4). Without a global consensus, the definition of basic indicators, metrics, and the costs and benefits associated with sustainable buildings tend to vary in the different methodologies and results of designing and benchmarking buildings and cities.

BARRIERS AND SOCIO-CULTURAL BEHAVIOR TRANSFORMATION

Lester R. Brown of the World Watch Institute describes sustainable living in the 21st century as "…shifting to a renewable energy-based, reuse/recycle economy with a diversified transport system".[3] Proponents of sustain-able living (with energy-efficient buildings) aim to conduct their lives in manners that are consistent with sustainability, in natural balance and respectful of humanity's symbiotic relationship with the Earth's natural ecology and cycles.[4] However, different socio-economic cultures, poverty, behavior patterns, and lifestyle are conquerable barriers to effective action-based policy implementations for measureable and comparable sustainable buildings and lifestyles. There is significant cost-effective potential for energy efficiency improvements in buildings (McKinsey IPCC, 2007). Six types of barriers to energy efficiency in the building sector widely exist:

1. Information barriers
2. Political and structural barriers
3. Behavioral and organizational constraints
4. Economic barriers
5. Hidden costs and benefits
6. Market failures

To successfully overcome these barriers we need more real-time-data-exchange of cross-country comparisons to provide a common language with accessible how-to-built-information for multistake holders. The data should include the different lifestyles and traditions of achieving sustainability and implementing policies in those countries. It is particular important that we elaborate the basic resource needs in Non-OECD countries by providing shelters for basic physiological needs. Once poverty needs become multi dimensional, many problems surface with the sum of all the basic components, such as shelter and access to common domestic resources. The most sustainable methods needed to include supply of basic needs which then lead to the design and construction of more efficient shelters, buildings and communities.

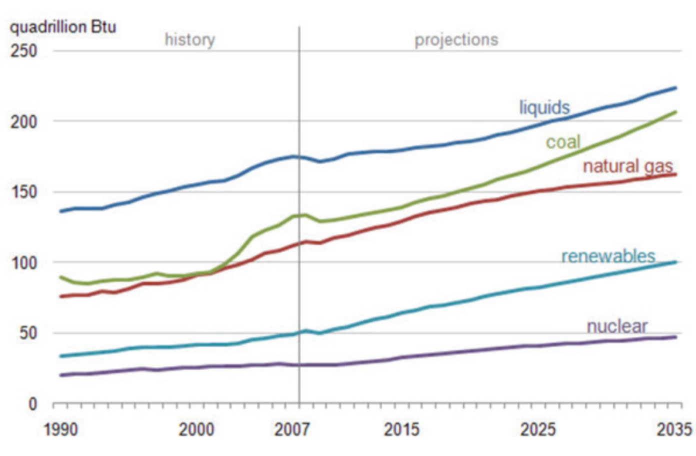

Figure 5. Source: International Energy Outlook 2010 (IEO 2010), World Marketed Energy Use by Fuel Type, http://www.eia.doe.gov/oiaf/ieo/, accessed on 4/6/2012.

MEASURING HOUSEHOLD AND TRANS-PORT ENERGY USE

According to the statistics of the U.S. Energy Information Administration International Energy Outlook (EIA-IEO 2010) the World marketed energy consumption might increase by approximate 49 percent from 2007 to 2035, and the total energy demand in non-OECD countries will increase by 84 percent, compared with an increase of 14 percent in OECD countries.[5] The reference does not include prospective legislation or policies, however it forecasts a world marketed energy consumption growth by 49 percent from 2007 to 2035 and total world energy use rising from 495 quadrillion Btu in 2007 to 739 quadrillion Btu in 2035 (Fig.4).

The forecasted statistics clearly shows that the driving forces of human-induced climate change are steadily increasing. Indicators of CO2 emissions have to be taken in account with regard to climate change through building energy use including the impacts of household energy use. Household energy consumption on other greenhouse gas emissions is smaller, usually indirect, and more difficult to analyze. Household consumption patterns need to be identified in order to reduce CO2 emissions and evaluate these patterns relative to the global building energy statistics. The assembled household energy data must include changes with regards to short term and long term factors. The short term factors of implementations in the building sector could be undertaken fairly quickly. This includes simple retrofitting techniques like lighting, insulation, and shading. Others such as fundamental changes towards carbon neutral building design, urban planning and transportation infrastructure will take year to become effective. The policy question will be not so much which of these to choose, but how much energy conservation and emission reduction can be achieved from each in ways that are technologically, socio-culturally, economically, and politically feasible.

Another policy question affects urban and transportation planning: The design and development of open areas far from urban cores and

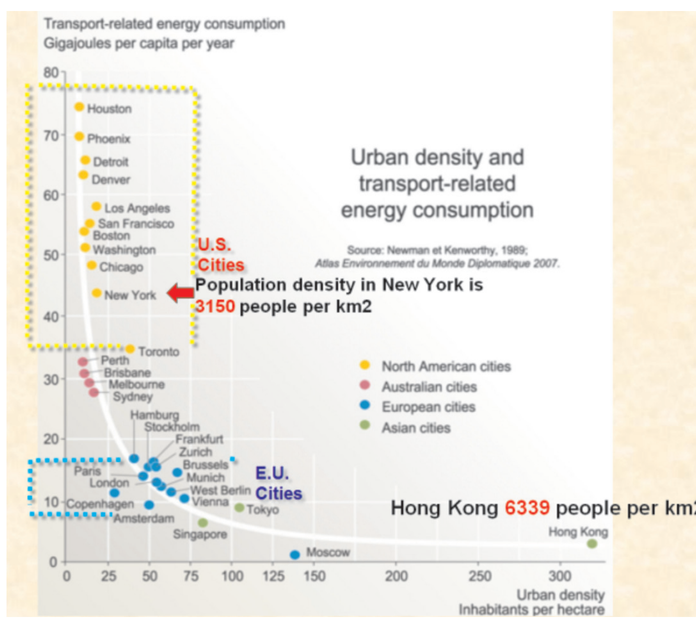

Figure 6. Lecture Slide for the Intl. Green Expo Chicago Conference, Thomas Spiegelhalter, in 'Global Benchmarking', Nov. 2010. Based on the Newman et Kennworthy, 1989, Atlas Environment du Monde Diplomatique 2007.

existing neighborhoods may reduce property costs, while resulting in negative consequences on the natural environment. This also causes building occupants to become more dependent on private transportation, and as travel distances increase, resource use and infrastructure systems increase. Mass trans-portation in urban areas reduces the impacts connected with traffic and congestion. It is imperative for the academia and the profession that we consider urban density and transport-related energy consumption in any Building Resource Performance assessment. Research shows that public transit is fiscally practical only with population compactness larger than thirty people per hectare. Many U.S. cities have 6 to 20 people per hectare, while large European, Asian and Latin American cities they have densities of 30 to 100 and more people per hectare. (Fig.5)

IMPLEMENTING LOCAL BUILDING ENERGY PERFORMANCE MONITORING AND YEARLY LABELING SYSTEMS

Most countries often begin with voluntary programs, then make building performance labeling mandatory as standards improve and producers and consumers become familiar with each system of energy conservation and building resource efficiency. To encourage customers in anticipating these types of yearly rating systems and labels helps them to understand better the information on actual measured building energy use as a public 'lessons learned'. This also helps them to recognize the monetary savings that can be accomplished through various conservation measures. Publicly accessible labels on building energy and carbon intensity affirm the well-organized models and the progress of the more resourceful planning models towards carbon neutrality. The customer is also able to compare the operating costs of all the different models with the help of the information labels when he intends to sell, buy or rent a property.

THE GROWING BUSINESS OF CARBON OFFSETS

There are several strategies to offset CO2 and reduce climate change for consumers, building owners and operators: For example by reducing heat islands and planting vegetation and trees in order to absorb more CO2. Or for those consumers and building operators that find it impossible to directly invest in renewable energy or other solutions, there are services available that sell carbon offsets. "The business of carbon offsets has been growing rapidly in recent years, with estimates of about $100 million per year on offset sales, and there are concerns about the reliability of some of the offsets, about a possible rebound effect that encourages people to indulge in energy-intensive activities as long as they are covered by offsets, and about the possibility that easy availability of offsets could undermine support for necessary changes in consumption and production patterns."[6] Sadly, there is no globally common regulation of these carbon offsets or climate credit cards at the moment; some are simply based on public voluntary standards or codes of conduct developed in cooperation with environmental organizations in different countries.

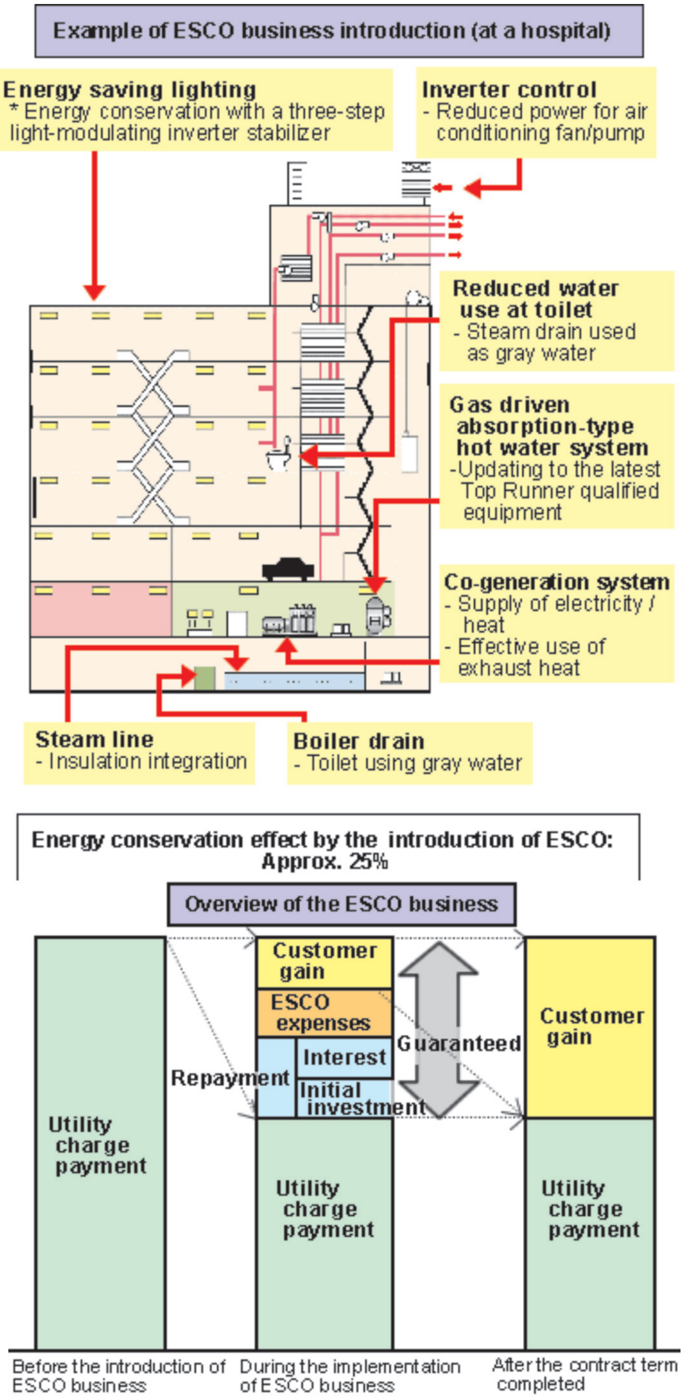

Figure 7. Energy Service Companies (ESCO's) Energy Efficiency Retrofitting Diagram, http://www.eng-forum.com/energy/esco/esco.htm, accessed 5/23/2012

ESCO'S ARE CHANGING CORPORATE BEHAVIOR

Today, an increasingly corporate behavior is globally more driven by public approaches of becoming sustainable, a trend for many corporations and governments to express their environmental apprehension and community liability. More and more Energy Service Companies (ESCO's) around the world offer advice and support on decreasing energy use. They get paid based on the financial savings, which usually originate from lighting, heating/ cooling, plug-load and water savings.[7] (Fig. 6)

Today's available technologies make it possible to have energy and water use efficiency in both new and old constructions. Very simple actions can be taken to recover ventilation, insulation, and natural lighting, if all of these factors are addressed, this can significantly save energy spending. Studies show that 90 percent of the buildings energy usage through its lifetime is devoted for heating, cooling, lighting and other electrical appliances. The other 10 percent is consumed during the construction and material manufacturing, plus the demolition period.

BEST PRACTICE EXAMPLE DATABASE

But how can those best practice examples be measured and compared from state to state, and from country to country? A worldwide accessible, interactive, and user-friendly international databases of peer reviewed (baseline) cases is needed to advance the whole field of holistic carbon neutral design and post-occupancy, building energy performance measuring with audited best practice examples. The database should include a cyber-data-infrastructure to create a joint environment for global, regional, and local building stakeholders to quantitatively assess, and rank building resource use and carbon intensity. It would be best if the future global benchmarking system would gather real performance data information in a common global comparable metric language rather than simulated data which is the present accepted data by most evaluation tools today. Another goal of a global benchmarking system should be to provide a comparison and information platform to demonstrate first the potential for sustainable performance improvements through affordable passive building design strategies and 'low-tech' friendly solutions based on local resources and climate conditions that are applicable to developing nations as an important goal to achieve balanced resource efficiency.

OECD-COUNTRY PRACTICE EXAMPLES: U.S. LEED AND ENERGY STAR RATINGS

In the U.S. resource efficiency measuring and policy development has changed in recent years. What started out as a charismatic environmental crusade has matured into an established sector of the construction industry. For example, the voluntary U.S. LEED rating system was developed by the U.S. Green Building Council (USGBC), and launched in 2000. It is a voluntary green building rating system, while some U.S.-governmental and city agencies use LEED as a mandatory rating tool. In general, the rating system provides third-party verification for communities and buildings for using strategies intended to improve LEED based performance bench-marking in metrics on a national average such as energy savings, water efficiency, CO2 emissions reduction, improved indoor environmental quality, and environmental pollution reduction.

The other rating system is the U.S. Energy Star program, which has become a national standard for energy efficient consumer product standard for mandatory building energy performance benchmarking. It was first created as a government program during in 1990s. The numbers of Energy Star occupancy types currently include bank/ financial institutions, courthouses, hospitals, hotels and motels, house of worship, K-12 schools, medical offices, offices, residence, dormitories, retail stores, supermarkets, and ware-houses.[8] All of these building types can receive their energy performance rating in the so called Portfolio Manager. It includes detailed assessment methodologies, and commissioning on a yearly basis, check its energy use, and rolling them into a rating on a 100-point scale. A building performing better than 60% of the stock would receive a 60. It remains unclear if the metrics can be further compared on a global level or if they only relate to the national U.S. EPA's peer buildings rating.

THE E.U. MANDATORY BUILDING ENERGY PERFORMANCE CERTIFICATE DIRECTIVE

One of the key driving forces of European energy-efficient design is the 2002 Energy Performance of Buildings Directive (EPBD), inspired by the Kyoto Protocol of 1997, which commits the E.U. to achieve Nearly Zero-Net-Energy Buildings in 2018 and to reduce CO2 emissions by 80-95% by 2050 as compared to 1990 levels. Each of the twenty-seven member's states of the EU is responsible for individual implementation of the EPBD through national laws including updating the curricula of learning institutions and codes of the professional world. The focus at this time is on reducing energy use directly and carbon emissions indirectly. The yearly certification inspections are publicly displayed when buildings are constructed, sold, or rented out, and the actual energy use certificate must be made available to the prospective buyer or tenant. The display certificate is valid for only one year, which means that the continuing title of 'Energy Efficiency' and low 'Carbon Intensity' has to be earned, based on national and European wide performance standards such as Low-Energy (30-60kWh/m2/a), Passive House (15-20kWh/m2/a), Zero-Net-Fossil-, or Plus-Energy-Buildings, which produce more renewable energy than they need. (Fig.7) The display includes the rating from a prior three-year period, so that building occupants, liable architects, building owners and operators can learn whether resource-saving improvements and CO2 reductions have been matched or not or if they need a scheduled energy retrofitting and financing plan. (Fig.8)[9]

One of the most vicious data and media driven certificate events is 'The Carbon Trust' in the UK, which publishes through their interactive 'Energy Bill Saver Property Finder Values' all public buildings with their annually respective carbon footprint. For example Sir Norman Fosters spectacular designed City Hall Building in London, who he labeled as 'virtually carbon neutral building' through the design phase and inauguration, received a poor 'D' in the public display energy certificate rating, because of its annually emitted 2,100 tons of carbon in 2010. (Fig. 8)[10]

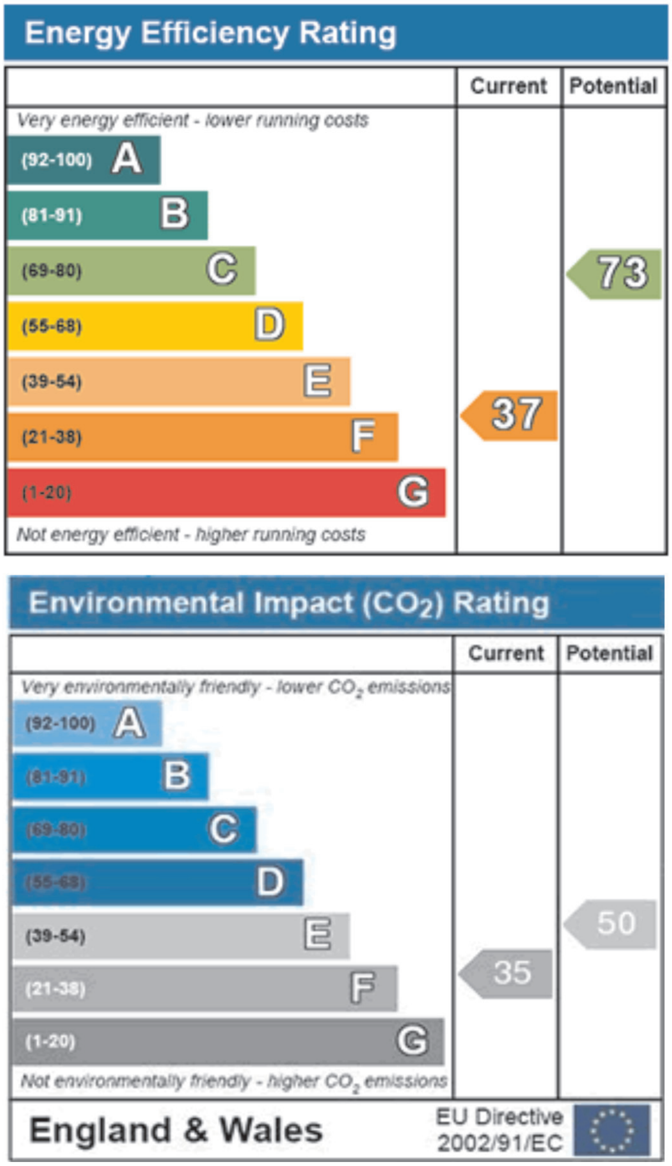

Figure 8. Excerpt of the typical European Building Energy Certificate Display. Source: UNEP 2012

Another example of implementing the Building Energy and CO2 certification are the mixed-use Solar Town Houses in the Solar City Freiburg, Germany, designed by the Author Thomas Spiegelhalter and built in 1996 (Fig. 9). The yearly conducted Energy Performance monitoring by the third party Agency MINOL found a full balance for the consumption of the Solar Town houses, with solar assisted thermal heating and electricity on the demand side and solar electricity generation on the generation side (energy credits). The data have been obtained from the local utility in the same way as for the so called EU Building Energy Display. The primary energy factor for electricity reflects the regional or national power system with its energy sources and efficiency. The average Solar Town house in the district of Rieselfeld in Freiburg has a primary energy balance of 53 kWh/(m2a). (Fig. 9).

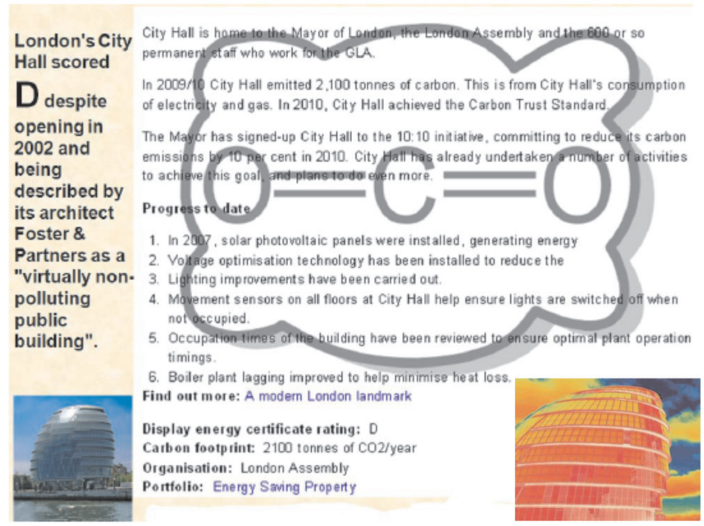

Figure 9. Norman Fosters Carbon Trust Rated and In-frared Analyzed City Hall in London, Source: http://www.bvenergysaver.co.uk/city_hall_london.html. Accessed on 12/28/2011.

DNGB BEST-PRACTICE EXAMPLE

The German Sustainable Building Council (DGNB) was founded in June 2007. It stands in competition to the already nationwide implemented mandatory energy saving ordinances and local sustainability initiatives in Germany since the eighties, which are deeply anchored in the early education and certification phases at Universities and the German Accreditation Boards for the licensing of architects after 5 years practice. The DNGB claims that their certification system is to be easily and practice-orientated adapted to the diversified requirements of other countries.[11] Buildings in one country with similar climate zones can still be compared to buildings in another. The criteria in the DGNB's core system define sustainable building design and ratings in six fields: Site Evaluation, Building Evaluation, Ecological Quality, Sociocultural and Functional Quality, Economical Quality, Technical Quality, Process Quality. (Fig.10, 11) In practice the DGNB certificates buildings based on specified principles that are identical for the assessment of all occupancy profiles with a catalog of 60 baseline criteria, with an emphasis on socio-cultural quality.

CONCLUSION

Despite the before mentioned nationwide implementations of diverse Building Energy Use and GHG's Rating Systems in the European Union and partly in the U.S., it remains essential to include to the building energy use also sustainable lifestyles, household and transportation energy use as an important data input and feedback loop (lessons learned) through annually and mandatory evaluations. In addition, training and further education of architects and engineers must be continuously related to these future needs of post-occupancy evaluations including life-style changes by different occupancy types. Schools, universities, and professional associations of multi-stakeholders in the building sectors are called

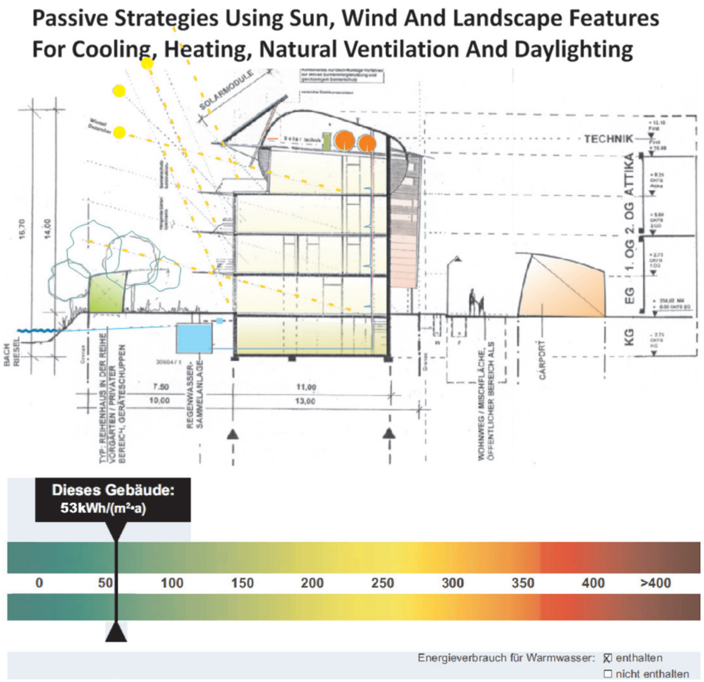

Figure 10. Solar Town Houses in Freiburg, Germany. Architect Thomas Spiegelhalter with Low Energy House Enclosure Systems, Green Facades, Solar Thermal and PV Energy Systems, Rainwater Collection and Real Energy Use Monitoring Systems

upon to develop collectively relevant core curricular at the earliest stages in the primary, secondary, and tertiary education systems. There is a main need to identify, understand and integrate social-cultural quality in their core curricular assessment, from a top-down or bottom-up approach to take up the same responsibilities to promote and achieve these critical global benchmarking goals.

Furthermore, annually GHGs emissions and GHG's reduction targets must be measured against global resource use budgets and based on an objective global benchmarking scale and tied to total energy use comparisons of the United Nations Framework Convention on Climate Change (UNFCCC) carbon emissions counting and ranking.

Global GHG's related to Building Energy Performance benchmarking means that only systems directly applicable to reliably measuring contributions to climate stability are valid, and more specifically approaches that embrace nearly a 1.3 ton per annum per person carbon dioxide-equivalent target by 2050 as compared to 1990 levels. This globally benchmarked target is based on a fundamental equity calculation: that on a per-capita basis, each person has only an annual 1.3 ton emissions allowance, if oceans and forests are to be able to neutralize excessive carbon emissions

In short, in order to achieve this ambitious goal of reducing building energy emission levels by 80 percent by 2050 it will require a major global effort for improving existing and present design by incorporating sustainable lifestyles as part of the social and cultural actualization of people and building users.

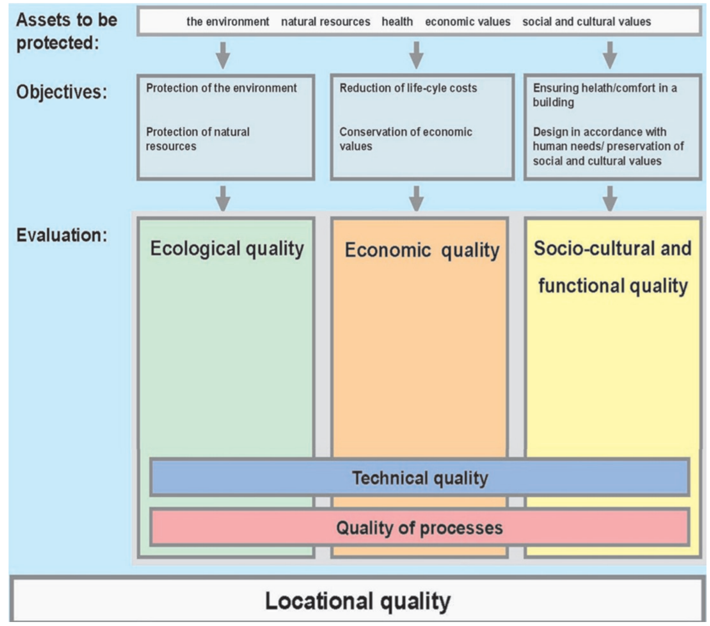

Figure 11. DNGB Evaluation Excerpt. *Source*: http://www.dgnb.de/dgnb-system/en/system/criteria/.
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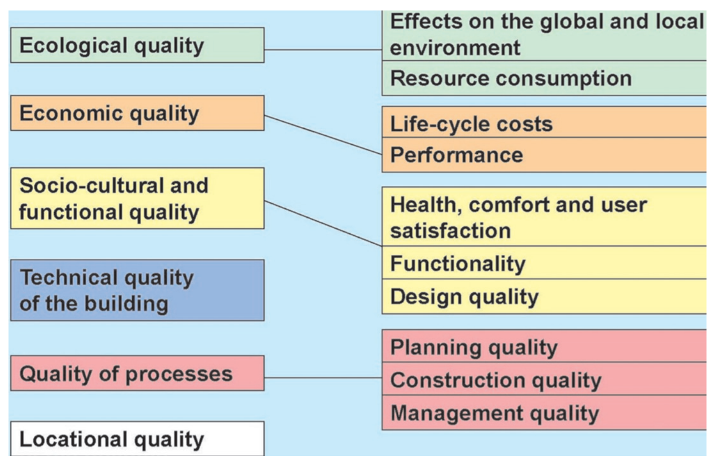

Figure 12. German Sustainable Building Labeling System. *Source*: http://www.dgnb.de/dgnb-system/en/system/criteria/.
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