CARBON HANDBOOK

Reducing
the carbon footprint
of world class events

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Editor-in-Chief
Craig Simmons

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The aim of the Carbon Handbook is to present a framework conducive to sound carbon management. It targets those responsible for developing and managing a carbon strategy for world class events (WCE). The Handbook covers everything from setting goals and targets to providing case studies, which illustrate how the others have succeeded in reducing the carbon emissions of their events. This document has been inspired by the Sochi 2014 Winter Games and based on the ample experiences and case studies gained during the preparation and staging the Sochi 2014, London 2012, Beijing 2008 Olympics, American Cup 2014, World Cup 2014 in Brazil and the others. At the same time it is necessary to emphasize that the Handbook is also relevant not only to sporting but also to other types of events: such as international conferences, exhibitions, festivals, etc.

The Handbook has been prepared as the part of the UNDP/GEF Project "Greening 2014 Sochi Olympics: A Strategy and Action Plan for the Greening Legacy".

Authors

A. Averchenkov (UNDP)
L. Averbukh (State Corporation on Construction of Olympic Venues "Olympstroy")
A. Bespalov (State Corporation on Construction of Olympic Venues "Olympstroy")
V. Berdin (International Sustainable Energy Development Centre under auspices of UNESCO (ISEDC))
S. Dunnett (Anthesis Consulting Group)
M. Dyubanova (Independent Consultant)
E. Matalon (Independent Consultant)
J.Shmeleva (Ecocentre IFPA)
C. Simmons (Anthesis Consulting Group)
G. Vatletsov (State Corporation on Construction of Olympic Venues "Olympstroy")
R. Watson (ECON Group)

Project Coordinators

Nataly Olofinskaya (UNDP)
Sergey Tambiev (UNDP/GEF Project "Greening 2014 Sochi Olympics")

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ISBN

The United Nations Development Programme (UNDP) is a global UN development network aimed at positively changing human life through provision of participating countries with access to knowledge, experience and resource.

The Global Environment Facility (GEF) is an independent financial organisation. The GEF provides grants to developing countries and countries with economies in transition for projects related to the global environment, linking local, national, and global environmental challenges and promoting sustainable livelihoods.

The Ministry of Natural Resources and Environment of the Russian Federation (Minprirody of Russia) is a federal executive authority performing functions of public policy making and statutory regulation in the field of the study, use, renewal, and conservation of natural resources.

Disclaimer

The analysis and policy recommendations in this Report do not necessarily reflect the views of the UN systems and other institutions by which the experts and consultants are employed.

Message from the Minister of Natural Resources and Environment of the Russian Federation

Dear Reader,

This publication has been prepared in the framework of the joint Project of the United Nations Development Programme, the Global Environment Facility and the Ministry of Natural Resources and Environment of the Russian Federation "Greening 2014 Sochi Olympics: A Strategy and Action Plan for the Greening Legacy".

The goal of this Project was to use the experience gained during the preparation and staging of the Sochi 2014 Winter Games to demonstrate, with the support of GEF and UNDP, our vision towards addressing the global environmental challenges, and contribution of the Russian Federation to the "Greening Legacy" creating.

The book you are holding in your hands - the "Carbon Handbook. Reducing the carbon footprint of world class events" is one of outputs of the Project.

The Project as a whole, and this Handbook in particular, are based on the Russian national commitments for the Sochi 2014 Winter Games regarding green-house gasses emission management and reduction. The commitments were aimed at achieving carbon neutrality of the Sochi 2014 Winter Games, what was formally reflected in the Winter Olympic Games Application of the Russian Federation.

Today the international community follows the principles of sustainable development and, in particular, to the low carbon development vector. All the recent world class sports events are no exception. Their organizers planned targeted large-scale activities for reduction of green-house gasses emission including countervailing measures. These allowed us neutralize that part of the carbon footprint that is almost impossible to avoid even by applying all the available carbon management tools.

Dear Reader! This Handbook will provide you with comprehensive and intelligible information on the existing international approaches and practices of carbon management at World Class Events. The Handbook will help you to learn about important tools of reduction of green-house gasses emission, about successful examples of the Sochi 2014 Winter Games, and earlier World Class Sports Events.

I wish you interesting and useful reading, which you might find practical to apply in your own area of interest.

Let us all together help prevent climate change and save our planet for future generations.

Minister of Natural Resources and Environment of the Russian Federation

Sergey Donskoy

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1. Acknowledgements

The Handbook has been prepared as one of the key outputs of the UNDP/GEF Project "Greening 2014 Sochi Olympics: A Strategy and Action Plan for the Greening Legacy" under the editorship of Craig Simmons, who also acted as a lead author. Craig co-founded the sustainability consultancy Best Foot Forward (BFF), now part of the global Anthesis Consulting Group. Craig is the Chief Technical Advisor at Anthesis.[1]

Lead contributors

This Handbook would not have been possible without the following experts (presented here in alphabetical order) who have made a substantial contribution to this Handbook:

Alexander Averchenkov (UNDP)
Lev Averbukh (State Corporation on Construction of Olympic Venues "Olympstroy")
Vladimir Berdin (International Sustainable Energy Development Centre under auspices of UNESCO (ISEDC))
Sebastian Dunnett (Anthesis Consulting Group)
Margarita Dyubanova (Independent Consultant)
Eric Matalon (Independent Consultant)
Alexander Naumov (Central Scientific-Research and Design Institute of experimental industrial buildings)
Nataly Olofinskaya (UNDP)
Sergey Tambiev (UNDP/GEF Project "Greening 2014 Sochi Olympics")
Robert Watson (ECON Group)

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1 Best Foot Forward is an award-winning sustainability consultancy which specialises in carbon and ecological footprinting.

2. Scope and target audience

This Handbook is aimed at helping those responsible for developing and managing a carbon strategy for world class events (WCE).

It covers everything from setting goals and targets to providing case studies which illustrate how others have succeeded in reducing the carbon emissions of their event.

Ample background information is provided for those unfamiliar with carbon management including evidence to help justify investment in low carbon operations and infrastructure.

The nature, scale and diversity of world class events means that it is not possible to be too prescriptive when giving advice. Each host City or Country will face their own challenges and enjoy certain advantages. For example, a compact location will face fewer transportation issues than one where venues are geographically dispersed. A Country which already has suitable venues will not be burdened with the environmental impacts associated with large scale construction projects.

The aim is to present a framework conducive to sound carbon management. Although this Handbook draws together the experience of many individuals, nothing can substitute for on-the-ground, local knowledge and an organisational commitment to deliver an exemplary world class event. This is not something that one person – or even a small team - can do alone. If the aim is to make a difference, then carbon management must be deeply embedded in the culture of the delivery agencies and partners.

Given that this document has been inspired by the Sochi 2014 Winter Games, the emphasis is necessarily focused on large sporting events.

Much of what will be discussed, though, is relevant to other types of events: concerts, conferences, exhibitions, festivals as well as smaller local activities.

It is not just about carbon

This Handbook covers just one aspect of sustainable event management. There are many other considerations. Events also need to:

- *Manage a range of other environmental impacts: water use, chemical use, waste disposal and so on*
- *Ensure safety and security of participants and spectators*
- *Encourage healthy lifestyles and more sustainable behaviours*
- *Protect and enhance the natural environment*
- *Procure goods and services responsibly*
- *Be inclusive and accessible to all*
- *Deliver a high quality visitor experience*
- *Consider workforce benefits; e.g. job creation, education and training*
- *Consider local and regional economic benefits*
- *Leave intellectual legacy in the host country, city, or communities*

A well-formed sustainability strategy would consider all these areas – not just carbon.

3. Climate Change and World Class Events

Climate change

In May 2013, carbon dioxide levels in the atmosphere exceeded 400 parts per million for the first time in several hundred millennia.[2]

While the goal of limiting global average temperate rise below two degrees centigrade still remains technically feasible, the International Energy Agency (IEA) estimates that the temperature increase compared to preindustrial levels is more likely to be between 3.6 °C and 5.3 °C.[3] The wealth of scientific literature, including the recent IPCC 5th Assessment Report , tells us that the impacts of the human-induced increase of greenhouse gases (GHGs) are disastrous for the global environment and human well-being:

- *The last 30 year period was likely the warmest in the last 1,400 years*
- *The sea level has risen by about 0.19m over the last century*
- *The Greenland and Antarctic ice sheets are losing mass, glaciers are shrinking and the Arctic sea ice and Northern Hemisphere spring snow cover are decreasing*
- *Ocean acidity is increasing*
- *There are more frequent heat waves in parts of the world*

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[2] http://www.unep.org/newscentre/default.aspx?DocumentID=2716&ArticleID=9503
[3] http://www.iea.org/media/freepublications/2013pubs/WEO2013_Climate_Excerpt_ES_WEB.pdf

Business as usual is not an option

The global climate is changing and we should expect that the current trends to continue and extreme weather events (such as storms, floods, and heat waves) to become more frequent and intense if no action is taken.

Actions to incrementally reduce GHG emissions are proving ineffective and inadequate. It is increasingly clear that the world needs a transformational shift that will lead to significant "decarbonisation" of the global economy. This will impact on all sectors and all countries. Sporting events are no exception.

The impact of weather vulnerability and climate change on events

The state of the environment can have significant impacts on sport. Athletes can be affected by adverse environmental conditions and exposure to harmful substances. The impact of the environment, and especially of climate change, becomes most obvious with winter sports – increased temperatures and poor snow cover already make it impossible to reliably engage in winter sports in many parts of the world. UNEP lists climate change amongst the three most common environmental threats to sports.[5] Common climate change-related threats to sport include:[6]

- *Reduced snow cover – winter sports rely on sufficient snow cover and good snow conditions.*
- *Retreating glaciers – this is a problem for those ski slopes on glaciers which offer both winter and summer skiing.*
- *Melting permafrost – this makes many mountain areas vulnerable to landslides and thus less safe for sport.*
- *Warming climate – this can mean increased rainfall in areas that would otherwise have experienced snow and hotter summers and increasing*

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5 http://www.unep.org/sport_env/about.aspx
6 www.unep.org/sport_env/documents/torinobuerki.doc

heat waves in warmer climates. Both potentially impact on sporting activities.

- *Unseasonal and extreme weather events – these are of concern to many planned activities, including sports, and can seriously disrupt an event itself as well as resulting in costly mitigating measures. For example, it may be necessary to implement flood management measures or enclose a venue to minimise the risk of disruption.*

Other, less direct, climate change-related effects can also impact on sports. For example, habitat and biodiversity loss may lead to the loss of natural areas to practice sport. Higher temperature can result in increased air and waterborne diseases that could affect the health of athletes.

"Without a doubt, winter is in trouble" [7]

A discussion paper released three years before the 2010 Vancouver Winter Olympics[8] highlighted the tangible impact of a changing climate on the events industry through a decrease in snow cover and more variable winter temperatures. When the Games were held in 2010, the organising committee, VANOC, were forced to implement extreme measures like trucking in snow to create a functioning course on Cypress Mountain (CBC News, 2010[9]). Similar preparations have been made by the Sochi organising committee.

Climate models developed by the OECD project a reduction in snow cover at lower altitudes, receding glaciers, and melting permafrost. 609 Alpine ski areas are considered to be naturally snow-reliable; this number would shrink to 500 with just one degree centigrade (1°C) of global warming (OECD, 2007).

Although Winter Sports are undoubtedly the most affected by climate

Winter in Trouble

The concern about the future of winter sports events in a changing climate has recently led to 75 American athletes writing to Barack Obama as part of the Protect Our Winters campaign (2013).

www.protectourwinters.org

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[7] www.protectourwinters.org

[8] http://www.davidsuzuki.org/publications/downloads/2008/Meeting-the-Challenge.pdf

[9] http://www.cbc.ca/news/canada/british-columbia/no-snow-at-olympic-site-leaves-vanoc-scrambling-1.918004

change, and likely to be so in the future, rising temperatures can also make otherwise comfortable climates problematic for athletes and spectators alike. High, and increasing, summer temperatures in Qatar were cited as the main reason for re-scheduling the 2022 World Cup to the winter months.[10] Concerns have also been raised about the viability of the Tour de France (see box).

Of course, the viability of events is also impacted by other problems which could be exacerbated by climate change. Events require reliable supplies of high quality food, water, energy and materials. The provision of all, or any, of these could be impacted by scarcity, disrupted supply chains and/or price volatility resulting in part from worsening climate change.

Climate change "bigger threat" to Tour de France than doping

Warming temperature in Southern France are claimed to be a greater threat to the Tour de France's future than doping with higher temperature making the condition untenable for cyclists.

Extreme weather has already impacted on a number of prominent cycling events including the Giro d'Italia where scores of riders crashed, in May 2013, during torrential rain.

Source: http://qz.com/103669/climate-change-is-a-bigger-threat-to-the-tour-de-france-than-doping/

[10] www.unep.org/sport_env/documents/torinobuerki.doc

The role of world class events in delivering change to sustainable development

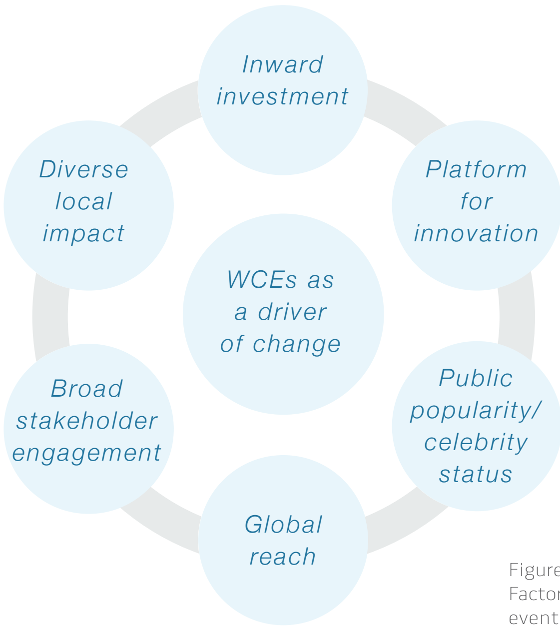

Figure 1.
Factors which make world class events ideal drivers of change

World class events provide a notable and high profile opportunity to break from convention and demonstrate how carbon management can be done in a different way. A combination of factors makes them ideal drivers of global change. These factors are given in Figure 1 and described further below.

"The power for good that sport represents can be harnessed and channeled to help make our world a better place."[11]

Major world class events, including sporting competitions, expos, and summits are hosted annually around the globe on all continents,

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[11] http://www.unep.org/sport_env/about.aspx

“Sport is increasingly recognized as an important tool in helping the United Nations achieve its objectives, in particular the Millennium Development Goals. By including sport in development and peace programmes in a more systematic way, the United nations can make full use of this cost-efficient tool to help us create a better world.”

Ban Ki-moon, United Nations Secretary-General

within all climate zones and by nations with developed, developing and transition economies.

Recognising its responsibility to promote sustainable development, the International Olympic Committee (IOC) considers the environment as an integral dimension of Olympism, alongside sport and culture. The IOC ensures that the Olympic Games take place in conditions that take into account the environment in a responsible way, and collaborates with the relevant public or private authorities, with the aim of placing sport at the service of humanity.[12]

Big events attract significant investment and a global audience. They can be transformational; providing a focal point for positive change and the opportunity to deliver a lasting environmental legacy as well as protecting those environmental assets that we already have.

The economic benefits of staging a world class event can be significant. According to research by PwC, the economic impact of an Olympics Games can be as high as 3% of GDP.[13] For most countries this translates into many millions, even billions, of dollars of new spending.

Opportunities to deliver carbon benefits are not just limited to the duration of the event. Table 1 indicates the main activities during the planning, delivery and aftermath of a world class event where carbon benefits can be realised.

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12 http://www.olympic.org/Documents/Reference_documents_Factsheets/Environment_and_substainable_developement.pdf

13 http://www.pages.drexel.edu/~rosenl/sports%20Folder/Economic%20Impact%20of%20Olympics%20PWC.pdf

Pre-Event	• *Infrastructure development and improvement* • *New building construction and refurbishment*
Event	• *Energy and transport management* • *Procurement of goods and services* • *Waste management*
Post-Event	• *Legacy improvements; for example, due to product and service innovation or improved construction norms and standards* • *Lasting benefits from new construction projects* • *Positive behaviour change inspired by the event*

Table 1. Main opportunities for making carbon reductions in the planning and delivery of a WCE

World class events can also be inspirational; originating and offering a showcase for new ideas. The Global Environment Facility (GEF) has invested more than US$38 million (and leveraged more than ten times this amount) to develop, prototype and implement environmentally sound technologies and initiatives at world events (see Figure 2).

The all-encompassing nature of world class events means that they offer many opportunities to demonstrate innovation. Large events often have diverse local impacts across a range of sectors including:

- *Construction*
- *Transport*
- *Waste*
- *Energy*
- *Food*
- *Information technology*

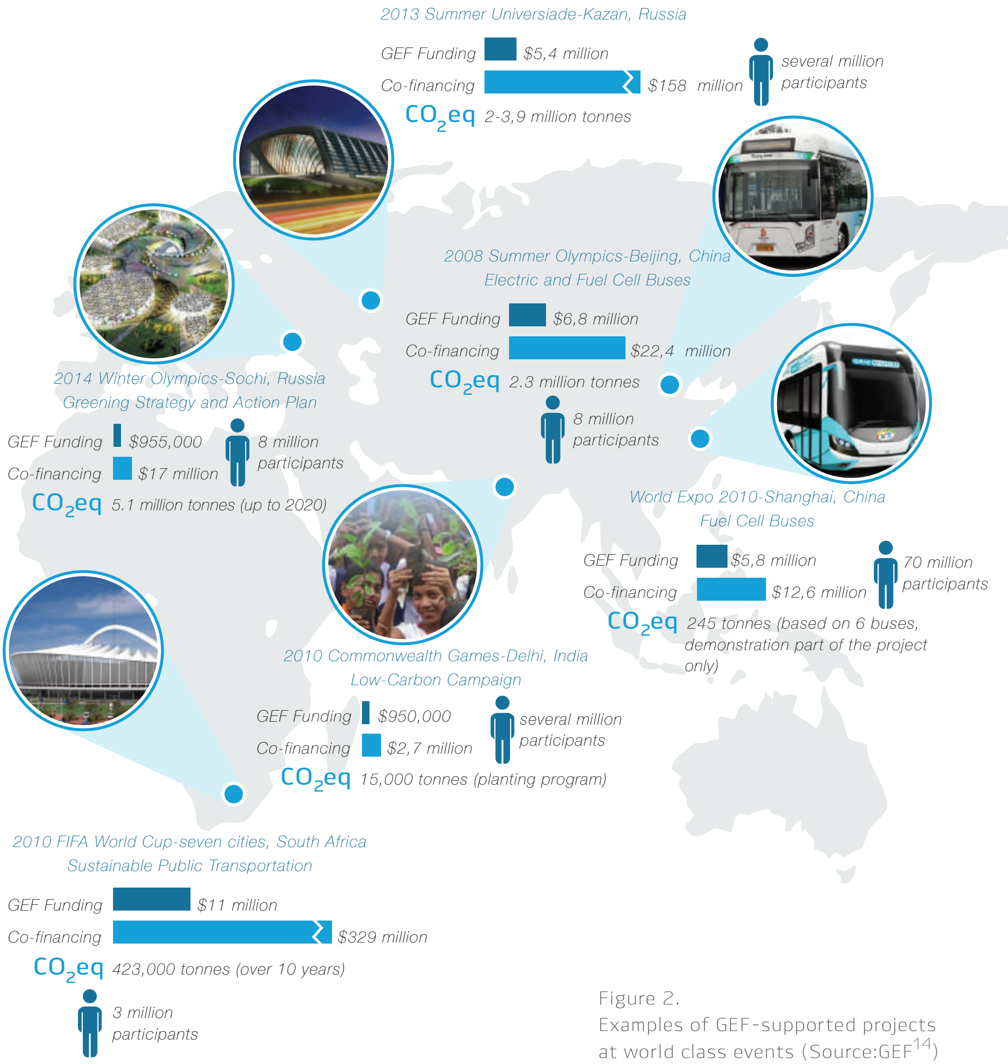

Figure 2.
Examples of GEF-supported projects at world class events (Source:GEF[14])

[14] http://www.thegef.org/gef/pubs/greening-opportunities-world-events-gef-investment-experiences

Another significant way in which sport can exert influence is through its popularity. Active and passive engagement in sport remains the most popular leisure pursuit with sport stars amongst the world's most recognised figures.

Their potential as ambassadors to promote a more sustainable way of living and to champion global environmental concerns is enormous.

Finally, WCEs can succeed in transforming the future through their ability to galvanise a wide range of stakeholders.

WCEs bring together Government, private corporations, 'third sector' organisations and a variety of interest groups and individuals. Such broad engagement is an essential element of delivering lasting change.

A force for good

The concern about the The Ellen MacArthur Foundation provides one of the best examples of an athlete using their stardom to engage stakeholders in delivering environmental change. The Foundation works in education, business innovation and analysis to accelerate the transition to a less damaging, more resource efficient "circular economy".

www.ellenmacarthurfoundation.org

Carbon risks and opportunities

In addition to the external risks from climate change, it is important to consider those mitigating actions that an event should take to reduce its own carbon footprint.

Risk assessment is already a core requirement of responsible event management and the exposure to carbon risk should be incorporated into existing processes and practices alongside other assessed risks such as safety and security. Failing to adequately plan for carbon risk can be both costly and environmentally irresponsible.

A framework for evaluating the likely carbon risks and opportunities for world class events is presented in Figure 3 below. This posits four main categories of risk: operational, reputational, regulatory and supply chain and gives three examples of each:

- *Operational: better operational management of carbon can lead to*

lower energy and material costs and less waste. Conversely, poor management can increase the costs and impacts in these areas.

- *Reputational: the sponsorship of world class events is strongly driven by reputation with environment now being a key consideration. Companies increasingly recognise the value of having a positive environmental brand. A poor reputation, with respect to carbon management, will also impact negatively on media relations and national credibility.*
- *Regulatory: internationally and nationally, greenhouse gases are the subject of voluntary and mandatory guidance and regulations. There is also a global market for carbon trading, which places a direct value on the cost of emissions. Good carbon management can minimise costs and maximise the opportunities that arise from market-based mechanisms (such as carbon trading, grants and subsidies).*
- *Supply Chain: it is important to recognise the carbon risks and opportunities that exist through the procurement process. For example, sourcing low carbon goods and services will reduce price volatility that arise from increases in the cost of energy. Specifying new, lower carbon, technologies will also support business innovation leading to wider economic benefits.*

North American Game Changers

The Natural Resources Defence Council's Game Changer report (NRDC 2012) highlights how North American sports teams are responding to environmental challenges whilst making a sound business case for change. Case studies show how teams are saving millions of dollars by:

- Direct savings in utility bills
- Attracting new sponsorship
- Attracting new clientele and partners
- Enhancing the fan experience
- Strengthening community ties
- Building local economic growth

See: www.nrdc.org

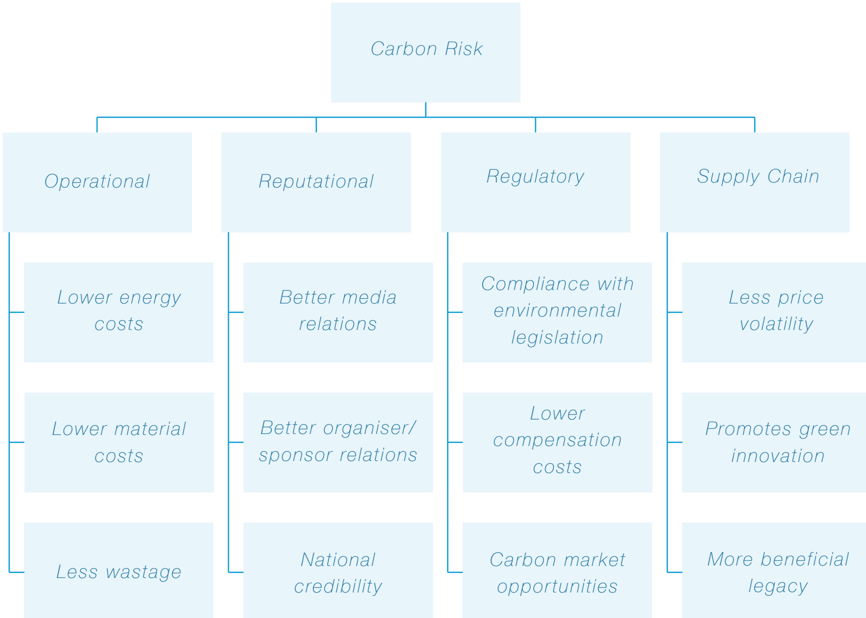

Figure 3. A framework for evaluating the carbon risks associated with sporting events

The proposed framework can be used to help identify and control risks. For example, the hosts of the London 2012 Olympic Games identified at an early stage the potential for reputational damage that could occur if its record on sustainability (including carbon management) was challenged. As a result, an independent body, the Commission for Sustainable London 2012 (CSL), was established to act as a 'critical friend' on sustainability issues.

It is widely acknowledged that CSL made a valuable contribution by providing independent assurance and commentary on London 2012's performance and reflecting the views of a wide range of stakeholders. One CSL review dealt directly with the carbon measurement and management.[15]

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15 Extinguishing Emissions? A review of the approach taken to carbon measurement and management across the London 2012 programme. http://www.cslondon.org/publications/?category=1&did=6

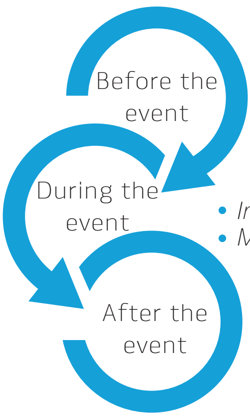
Under the auspices of the UNDP, Sochi 2014 worked with international experts to explore the opportunities available within national and international agreements to maximise carbon market opportunities and identified several viable options for compensating the event's residual carbon emissions in a cost-effective manner.

The 34th America's Cup worked with the host City, San Francisco, to jointly fund new power infrastructure thereby reducing the need for temporary generators; minimising operational risks whilst guaranteeing a long term legacy use for the newly installed energy supply system.

4. Creating an event carbon management strategy

Basic principles

Figure 4 below sets out the basic principles that represent good practice for carbon management before, after and during an event.



- *Identify potential carbon risks, opportunities impacts and issues*
- *Put in place early actions to avoid and reduce carbon*
- *Engage stakeholders*

- *Implement event-related actions*
- *Measure and monitor emissions*

- *Report carbon emissions*
- *Document other learnings*
- *Implement and monitor legacy projects*

Figure 4. Carbon management key activities before, during and after an event

As with all aspects of event management, planning and preparation are key.

Most of the effort needs to be expended well before an event is staged to identify potential issues and put in place early mitigating actions. This is also the time to put in place arrangements to scrutinise the environmental aspects of the event by engaging stakeholders in the decision-making processes.

Whilst there are no independent, internationally agreed, standards for measuring the carbon footprint of events, general frameworks

such as ISO20121 (championed by London 2012) are useful in helping to identify priority action areas and ensuring that the correct environmental management systems are in place.

Similarly, the Global Reporting Initiative Event Organisers Sector Supplement (GRI EOSS[16]) provides a robust reporting framework that can be used to transparently report performance including carbon emissions.

More generic greenhouse gas (and carbon) accounting standards (for companies, products and supply chains) can also prove useful in understanding how to undertake a carbon footprint analysis and act on the results. Information is provided in this document on the relevant Greenhouse Gas Protocol[17] and ISO standard ISO 20121.[18]

Aims and goals

ISO 20121

The ISO 20121 standard Event sustainability management systems – Requirements with guidance for use replaces the earlier BS8901 specification. It was both inspired and championed by the London 2012 Olympic and Paralympic Games. ISO 20121 is industry-led, helps ensure that an event leaves a positive legacy, and covers a wide spectrum of event sizes from local celebrations to “mega events”, such as the London Games.

ISO 20121 provides a framework to identify potential negative social, economic, and environmental impacts of events by removing or reducing them, whilst encouraging more positive impacts through improved planning and processes.

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16 https://www.globalreporting.org/resourcelibrary/EOSS-G3.1-SummaryGuide-QRS.pdf
17 http://www.ghgprotocol.org
18 http://www.iso.org/iso/catalogue_detail?csnumber=54552

Greenhouse Gas Protocol

Developed by the World Resources Institute and the World Business Council for Sustainable Development, The Greenhouse Gas Protocol: A Corporate Accounting and Reporting Standard is the most widely used international accounting standard for governments and business. Sister standards deal with products and supply chains.

The Greenhouse Gas Protocol was used as the basis for developing the London 2012 carbon footprint methodology. The International Organization for Standardization (ISO) presents an alternative approach to calculating a carbon footprint. The standard comprises three parts:

1. ISO 14064-1: 2006 specifies principles and requirements at the organisation level for quantification and reporting of GHG emissions
2. ISO 14064-2: 2006 specifies principles and requirements and provides guidance at the project level for quantification, monitoring and reporting of activities
3. ISO 14064-3: 2006 specifies principles and requirements and provides guidance for those conducting or managing the validation and/or verification of GHG assertions.

See: www.ghgprotocol.org and www.iso.org

Although measurement and reporting are important, the primary purpose of a carbon management strategy is to avoid and reduce carbon emissions as far as possible. Any strategy should establish clear carbon reduction hierarchy to guide decision-making (see Figure 5 below).

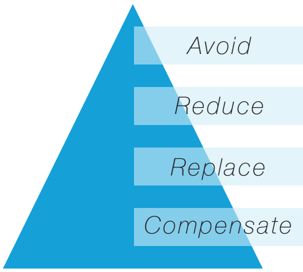

Figure 5.
Carbon reduction hierarchy

Avoid: eliminate entirely potential emission sources. For example, by deciding to make a venue car-free or scheduling events to reduce the number of venues required.

Reduce: optimise efficiency in energy use, transport, materials and work practices. For example, making the best use of a vehicle fleet by eliminating unnecessary journeys or designing a venue to minimise the use of materials.

Replace: introduce lower carbon materials and technologies. For example, use electric vehicles, renewable energy and natural materials.

Compensate: implement measures to deal with residual or unavoidable emissions and promote behaviour change.

Therefore, the priority is to try and predict where significant emissions could arise and avoid them whenever possible. Only if the emissions could not be eliminated should measures be put in place to reduce them, use substitute technologies to mitigate them or, as a last resort, seek to compensate for them through other means.

It may be appropriate to set a specific reduction target against an established and agreed "baseline" or Reference footprint. This can be guided by national or international greenhouse gas targets. However, targets can also be counterproductive as they can hinder wider efforts to track down and eliminate emission sources.

Before committing to calculate the carbon footprint of a world class event, it is recommended that WCE's organisers first familiarise themselves with existing approaches to company greenhouse gas

accounting. Many countries have their own preferred approaches, but these are invariably based on the Greenhouse Gas (GHG) Protocol or ISO14064. Both of these are internationally-agreed documents.

The underpinning principles from corporate GHG accounting are equally relevant to WCEs (see Figure 6).

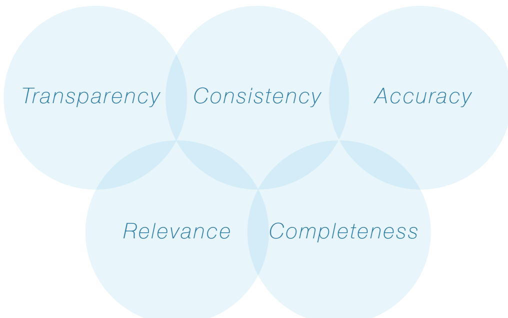

Figure 6. Greenhouse gas accounting: underpinning principles

Relevance - The boundaries for the carbon analysis should be chosen so as to include those elements over which there is influence and/or control. In this way, all information relevant to managing the event's carbon footprint falls within scope.

Completeness - To ensure full coverage, you should base the carbon reporting categories on the financial accounts (such as those contained with the original bidding document). In this way, the carbon impact of every item of expenditure will be accounted for. This is not to say that every item will have an associated carbon footprint. Some items will have a negligible impact – for example, some contracted services. However, it is important to recognise these by setting a "materiality threshold"; a financial and/or carbon threshold below which an item will be excluded.

Consistency – Measurement and re-measurement of the footprint should use a well-documented methodology and a consistent set of assumptions.

Accuracy - Unlike a standard corporate carbon report, which typically deals with historical data, event footprints are predictive. Accuracy is therefore a key concern. To address this, all data should be quality assessed and this information published alongside any carbon footprint estimates.

Transparency - Engagement with stakeholders and technical experts from the outset of any project will contribute to the acceptability and objectivity of the process. Stakeholders also provide a degree of challenge which will help test assumptions, methodology and data estimates.

Measuring and monitoring WCE footprint

Figure 7 sets out the process for measuring and monitoring event carbon emissions.

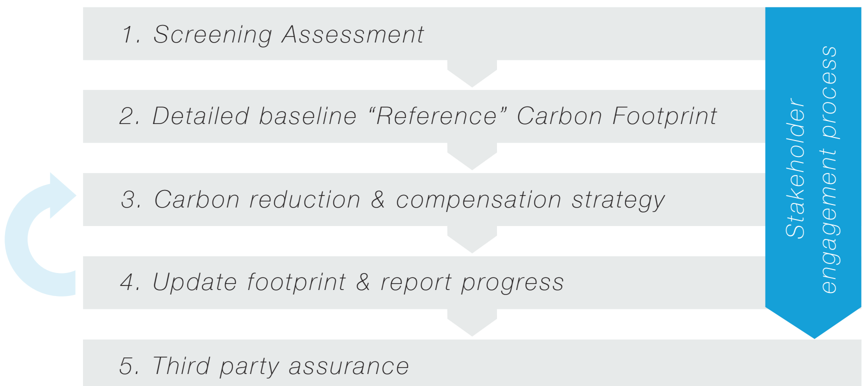

Figure 7. Process for measuring and monitoring event carbon emissions

Undertaking a screening assessment

It is good practice to undertake a screening assessment at the earliest opportunity.

A screening assessment is a very rough early estimate of an event's predicted carbon footprint. It helps to establish boundaries, as well as emission sources and suitable carbon conversion factors (the factors used to convert activity data into the equivalent greenhouse gas emissions). Most importantly, it assists in the early identification of those emission sources which are likely to contribute most to the overall footprint. These emission "hotspots" should be core to any Reduction and Compensation Strategy.

Influence & Control Example

As part of a sponsorship deal, an energy company provides "free" electricity to the venues managed by the event authority. Although the energy still, in one sense, "belongs" to the energy company it is the organisers who should take responsibility for reducing the carbon emissions associated with the use of the electricity as they have more influence and control over how the energy is utilized.

Screening assessments use the best available data, but at such an early stage, this data is often very low quality. However, for those events where a screening assessment has been conducted it has proven to be accurate enough not to warrant any substantial methodology changes when better data became available.

At this stage it is also important to clearly assign responsibility for emissions, and hence reductions, in a transparent and credible way. The many and complex contractual and sponsorship arrangements which necessarily form part of the funding and delivery of WCE make the assignment of responsibilities more complex than they would be for a more conventional organisational footprint where ownership is much clearer.

For this reason the use of emission "scopes", as set out in the Greenhouse Gas Protocol and other related standards, is less meaningful. Instead it is recommended that each partner is considered a separate entity with responsibility for those emissions over which they have most

Estimating a baseline Reference carbon footprint

A screening assessment, although useful in the early stages, is not usually of a sufficiently high resolution to be used as a baseline against which to measure reductions and track progress on an on-going basis. A more robust footprint, often called a Reference Footprint, is therefore needed.

Whatever methodology is used to estimate the Reference Footprint it should follow clear accounting guidelines. The London 2012 Carbon Footprint Methodology,[19] developed as a legacy document, is the most comprehensively documented approach to event carbon footprinting. Based on the GHG Protocol referred to earlier, it has been used with a number of other world class events including Sochi 2014, Rio 2016, the America's Cup and Brazil 2014 World Cup. As such, it currently represents best practice.

The London 2012 method sets out 15 accounting principles which are summarised below. Full details are on the London 2012 legacy site[20] (alongside many other useful resources).

1. Comply with the underpinning principles of the Greenhouse Gas Protocol and ISO 14064-1: Relevance, Completeness, Consistency, Accuracy and Transparency.
2. Use a suitable financial framework (for example, the financial plan produced during the bidding process) to help identify projects and activities that are likely to generate a carbon impact.
3. Account direct and indirect emissions (Scopes 1, 2 and 3). As far as possible, account for all Kyoto Protocol Greenhouse Gases. Report all results in tonnes of carbon dioxide equivalents or tCO_2e.
4. Set the study boundaries widely to include those elements over which the world class event has control or influence. As far as possible, allocate the emissions into three categories: "owned", "shared" or "associated" based on who is responsible for generating them.

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19 http://learninglegacy.independent.gov.uk/documents/pdfs/sustainability/cp-london-2012-carbon-footprint-methodology-and-reference-footprint.pdf

20 http://learninglegacy.independent.gov.uk

5. Establish a structured method for deciding what is in, and out, of scope.
6. Identify contentious carbon accounting issues early on to allow time for research & consensus building. Document the decision making process.
7. Establish a well documented reference footprint against which reduction measures can be accounted. Ensure that the data used to construct the reference footprint is relevant, credible and defensible.
8. Reduction measures must be transparently documented, amended and linked to a clear time horizon. Double counting should be avoided. The corresponding reference footprint assumptions should be clearly stated.
9. Identify a consistent dataset of carbon conversion factors for use throughout the carbon management strategy process. Ensure that these cover all Kyoto Protocol greenhouse gases, direct and indirect emissions, and include a data quality assessment. Use commonly available, standard datasets where possible with tools to support and facilitate data sharing and integrated planning.
10. The carbon conversion factors used should be responsive to local circumstances. Rules about how to account for, for example, renewable energy, are not universal. These can change as new guidance emerges and may differ within, and between, countries.
11. Account emissions in the year that they occur, allocating them to categories as appropriate. Responsibility for these emissions should be established and clearly documented.
12. Longer-lasting benefits are legacy carbon savings as a result of projects or initiatives funded by a world class event. To count as long-term carbon savings, these must be additional.
13. Document levels of uncertainty attributable both to poor quality data and uncertainty in the carbon conversion factors used and implement quality control measures.
14. If necessary, annually report on the carbon footprint. Clearly document any data, methodology or scenario changes.
15. Establish key performance indicators. These will allow the comparison within, and between, other world class events and allow the overall effect of specific reduction measures to be quantified.

Reducing and compensating for the carbon footprint

The results from the Reference Footprint will help to both frame the context for existing reduction commitments and inspire new ideas. Some ideas may have already been thought of, others may require further investigation.

Reduction measures should comply with the hierarchy set out earlier. They should first attempt to avoid emissions, for example by eliminating the need for travel. If this is not possible then they should seek to lower emissions by improvements in efficiency or the use of alternative solutions. Finally, if these opportunities are not practical or possible, the emissions should be compensated (see Figure 8 below).

Out of scope: the importance of clearly defining boundaries

Around two billion people worldwide watched the Beijing Games on TV. This could alone have resulted in emissions of more than one million tonnes of CO_2. But should this significant source of carbon emissions be included in Beijing's footprint? Probably not as, although it is clearly attributable to the Games' organisers influence or control.

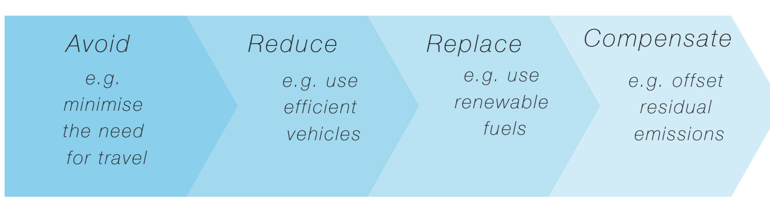

Figure 8. Priority actions for reduction measures

The later part of this Handbook provides examples of reduction measures which other WCEs have implemented.

The Reduction and Compensation Strategy should document all reduction measures through this decision-making process. It is helpful to think of such measures as evolving. First, they are ideas, and then challenges before becoming commitments. Once they are implemented they can be claimed as achievements (see Figure 9).

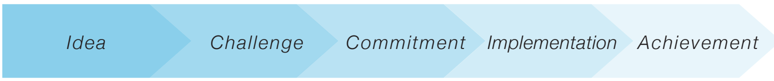

Figure 9. Process of developing and implementing a reduction measure

At the point which ideas become challenges the level of potential carbon savings should be quantified and collated together with other potential reduction measures to form a “reduction footprint”. This should be monitored and tracked through regular updates and reports. Implementation should be robustly evidenced to ensure that the potential carbon savings are realised.

Reductions Accounting

Reductions should only be claimed where there is clear evidence that they represent a genuine deviation from the Reference Footprint.

It is important that reduction measures are:

- *Clearly documented – assumptions and conversion factors should be properly sourced;*
- *Open to scrutiny – it is important that there is broad stakeholder agreement on the efficacy of the intended intervention;*
- *Not double counted – for example, counting energy savings under both venues and operations;*
- *Linked to a specific time period – for example, a saving may occur only during the Games or persist for some years afterwards.*

Useful further guidance on establishing baselines and evidencing reductions is available from the GHG Protocol for Project Accounting.[21] This proposes a clear process with each activity aimed at delivering reductions documented in the following manner:

- *Description of Activity: a summary of the actions or interventions intended to deliver a greenhouse gas reduction including boundary description.*
- *Emission sources: the emissions sources that will be impacted by the intended greenhouse gas reduction measures.*
- *Baseline scenario: emissions that would "most likely" have arisen without the intended actions/interventions to mitigate emissions.*
- *Primary greenhouse gas effects: intended quantum of emission reductions compared to the baseline – arising from the planned actions/interventions.*
- *Secondary greenhouse gas effects: any unintended greenhouse gas emissions (side effects) due to the planned actions/interventions. Note these are split into "one-off" and "recurring" changes.*
- *Data quality/materiality threshold: a summary of the data quality and materiality thresholds applied.*

The following example in Table 2, adapted from the 34th America's Cup, illustrates the application of this approach to evidencing reductions. In this case, the design of some steel piling was changed to reduce the amount of material required – hence avoiding the embodied carbon emissions in the saved steel.

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21 See www.ghgprotocol.org.

Description of project activity	The design of the floating docks has been improved to reduce the length of 36 steel piles by 10 feet each.			
Emission sources	The reduction in the use of steel will avoid the embodied emissions associated with the piles.			
Baseline scenario	The reference footprint assumes the 36 piles were each 90' long			
Assumptions	Pile sectional area: 0.03 m^2 (Based on a diameter of 16'' and a thickness of 0.5'') Density steel: 7,850 kg/m^3 (Source: www.engineeringtoolbox.com) Emission factor, steel: 2.03 $kgCO_2$-e/kg (Source: Best Foot Forward)			
Primary GHG effects		Baseline	Reduction	Savings
Length (foot)		90'	80'	10'
Weight of a pile (kg)		6,874	6,110	764
Carbon footprint per pile (tCO_2-e)		14.0	12.4	1.6
Total carbon footprint all piles (tCO_2-e)		502.4	446.6	55.8
Savings from this reduction measure		55.8 tCO_2-e		
Secondary GHG Effects		No secondary GHG effects have been identified.		
Data quality/ materiality threshold		The dimensions of the piles are provided by the event authority and are of high quality, as are the density and emission factor used.		

Table 2. Tracking a reduction measure - an example from the 34th America's Cup

Compensating for the residual footprint

Inevitably, there will be a residual footprint from hosting any large event regardless of the reduction measures implemented.

When companies want to do something about their residual carbon footprint, the usual response is to purchase "carbon offsets". Carbon offsets are tradable carbon credits which originate from projects where there has been an investment in carbon saving measures. For example, reforestation or new renewable energy installations.

Fans without footprints™

Fans Without Footprints is an innovate initiative that seeks to promote behaviour change amongst sports fans whilst offering them the opportunity to contribute to a green community project.

The programme offers both carbon savings tips and the opportunity for fans to balance their environmental footprint - or Fanprint™ through local action.

www.fanswithoutfootprints.com

This is still an option for WCEs. However, large events are in the position of being able to originate their own emission savings schemes which may, or may not, result in tradable carbon credits.

This provides more flexibility for those WCEs wishing to compensate for their emissions in ways which have other tangible legacy benefits. However, any savings that are generated will not be eligible to be traded on any existing voluntary or compliance carbon markets.

There are many other means by which a WCE can deliver lasting carbon benefits:

Knowledge transfer: actively sharing learnings for carbon savings with other event organisers can lead to improvements elsewhere.

Reuse of assets: donating or selling items to, for example, schools or local clubs extends their useful life hence reducing the need for new purchases.

New, low carbon energy and transport infrastructure: this will result in avoided emissions extending far beyond the closing ceremony.

Local energy efficiency and retrofit projects: *for example, insulating local buildings or investing in new recycling facilities will lead to lasting savings.*

Behaviour change campaigns: *For example, using the event to encourage more energy efficient behaviours or educating about the threats posed by climate change. This can also apply to delivery partners whose approach to carbon management may change as a result of their engagement in a WCE.*

Partner carbon offset initiatives: *In London, the appointment of an official offset provider, BP Target Neutral, accompanied by a spectator engagement programme, resulted in the setting of a new record for the largest number of journeys offset to any single event. It also encouraged partners and sponsors to consider offsetting.*

Declaring carbon neutrality

A number of world class events, including Sochi 2014, have committed to make all or some of their activities "carbon neutral". It is important that any such claim is fully, and independently, verified to ensure credibility and transparency.

PAS 2060,[22] from the British Standards Institute is the first, and currently only, internationally recognised standard with which world class events can independently demonstrate their commitment to, and achievement of, carbon neutrality. PAS 2060 defines carbon neutrality as net zero emissions.

[22] PAS 2060:2010 Specification for the demonstration of carbon neutrality. Available from: http://shop.bsigroup.com/ProductDetail/?pid=000000000030198309

Note that the declaration process defined by PAS 2060 is closely aligned with that described earlier for measuring and monitoring your carbon footprint. The PAS 2060 process is comprised of four broad stages:

1. Scoping: identification of included activities for which carbon neutrality is to be claimed.
2. Carbon footprinting: undertaking the measurement and monitoring process described earlier.
3. Offsetting: purchasing qualifying carbon offsets.
4. Carbon neutrality declarations: issuing an appropriate declaration.

Once an event has estimated its Reference footprint, PAS 2060 requires that the event authority issues a statement committing itself to carbon neutrality. An example is given in Figure 10 below. This is done pre-event.

Post-event, once the carbon offsets are purchased (or other eligible measures are taken, as defined in PAS 2060), a statement of achievement of carbon neutrality is issued. This must include the final event footprint as well as noting the reductions achieved by the carbon reduction and compensation strategy.

The 34th America's Cup recently became the first world class event to declare carbon neutrality using PAS 2060. Event organisers chose to "neutralise" the emissions associated with their San Francisco activities by partnering with Canadian firm Offsetters to source high quality carbon credits with which to address residual emissions.

Sourcing carbon credits

PAS 2060 requires that the carbon credits used to offset residual emissions are of a high quality and comply with strict criteria.[23] These include:

- *Credits must represent genuine, additional GHG emission reductions elsewhere*
- *Projects involved in delivering carbon credits shall meet the criteria of additionality, permanence, leakage and double counting*
- *Credits must be verified by an independent third party*

World Games 1: DECLARATION OF COMMITMENT TO CARBON NEUTRALITY

The carbon neutrality of the 1st World Games will be achieved by the organising committee in accordance with PAS 2060 for the period of 2008 to 2014.

Supporting information, including the planned means of achieving greenhouse gas emissions reductions estimated at 100,000 tCO_2-e, is available in the report entitled: 1st World Games Reference Carbon Footprint (Interim). The residual carbon footprint to be offsets is currently estimated to be 400,000 tCO_2-e.

World Games 1: DECLARATION OF ACHIEVEMENT TO CARBON NEUTRALITY

The carbon neutrality of the 1st World Games has been achieved by the organising committee in accordance with PAS 2060 for the period of 2008 to 2014.

The emissions of 100,000tCO_2-e were avoided as a result of reduction measures implemented by the organising committee; the residual emissions, amounting to 400,000 tCO_2-e, were offset.

Supporting information substantiating this declaration is available in the report entitled 1st World Games Reference Carbon Footprint (Final).

This declaration is made by Anthesis Consulting Group

Signed, World Games Committee

Assured by Anthesis Consulting Group

Figure 10.
Example declarations of commitment to, and achievement of, carbon neutrality for the fictional "World Games"

[23] For full details, see the PAS 2060 documentation

Updating and reporting progress

The frequency and nature of reporting will depend on the type of event. For large events, annual reports which provide updates on the Reference Footprint, reduction measures, and overall progress on these, are warranted. Reports should at least include the following information:

DESCRIPTION OF THE ASSUMPTIONS BOUNDARIES

- *An outline of the boundaries chosen, including the approach used to determine what is in, and out, of scope.*
- *An outline of the operational boundaries chosen, and whether upstream and downstream, supply chain emissions are included.*
- *A list of all emission sources included.*
- *Details of the emission factors used.*
- *Details of the competent persons undertaking the analysis and the responsible person within the event organising committee.*
- *The reporting period covered.*

INFORMATION ON EMISSIONS

- *Total emissions broken down as appropriate to allow the reader to identify emission hotspots and the effect of any reduction measures.*
- *Emissions data for all seven GHGs (CO_2, CH_4,N_2O, HFCs, PFCs, SF_6, NF_3) in metric tonnes and in tonnes of CO_2 equivalent.*
- *Details on emissions trends including any previous carbon footprints.*
- *Progress on reduction commitments and achievements and their likely influence on the reference footprint*
- *Details of any significant changes that would trigger reference footprint recalculations (for example changes in boundaries or calculation methodology)*
- *Details of the methodology and tools used*
- *Details of specific exclusions*
- *An assessment of data quality*

It is important to be aware of the audience for any report. Different levels of detail, style and content may be appropriate for different groups. Possible audiences include:

- *General public*
- *Policy makers*
- *Environmental experts*
- *Delivery partners and sponsors*
- *Assurance provider*
- *GHG reporting programmes (note that the IOC requires Olympic Games to report greenhouse gases as part of their Olympic Games Impact reports.*

Global Reporting Initiative Event Organizers Sector Supplement (EOSS)

As the name suggests, the GRI EOSS provides a framework for the sustainability reporting of events. It covers these broad themes: economic, environment, society, product responsibility, sourcing, and legacy. The guidance includes the following performance indictors relevant to carbon:

- EN16 Total direct and indirect greenhouse gas emissions by weight
- EN17 Other relevant indirect greenhouse gas emissions by weight
- EN18 Initiatives to reduce greenhouse gas emissions and reductions achieved

Assuring the results

The verification of an event carbon footprint, both the results and the calculation process, will instill confidence in the data and conclusions. Two key parties are involved in the assurance process:

- *The reporting organization seeking assurance*
- *The assurer(s)*

To increase the credibility of the findings, events authorities should instruct an external organisation to assure the footprint; even if they have chosen to calculate the footprint by themselves. This is known as third party assurance.

Third party assurers should be competent, independent and free from conflicts of interest.

The outcomes of an assurance exercise will vary depending on the scope of the exercise and the level of assurance required. However, most will include the following elements:

- *A clear description of the assurance process and any standards used*
- *A critical review of the carbon footprint methodology, data and assumptions*
- *A list of errors or omissions and whether these are considered material with respect to the results and conclusions*
- *Variations from any relevant standards or guidelines; for example the London 2012 accounting principles*
- *An assurance statement – indicating the level of confidence in the results*

Stakeholder Engagement

Stakeholder engagement should not be perceived as a "burden" but as adding value to the process:

- *Improved communication between organisers and external organisations.*
- *Enhanced reputation through transparency and openness.*
- *An excellent source of new means and ways of achieving carbon reductions.*
- *A useful "sounding board" to test out alternative carbon management options.*

Stakeholders can initially be categorised into two broad groups:

- *Key stakeholders: organisations or individuals with accountability for delivering one or more of a carbon management strategy's objectives.*
- *Wider stakeholders: organisations with a legitimate interest in the management of carbon at the world class event.*

A Carbon Technical Advisory Group

London 2012 was the first world class event to set up its own carbon technical advisory group. This consisted of sustainability sponsors, academics, government representatives and NGOs. It helped to resolve complex carbon accounting issues and, in doing so, enhanced the credibility and independence of the approach taken to carbon management.

Beyond this simple classification, stakeholders can be further sub-categorised into smaller groups. London 2012 identified twelve distinct stakeholder groups (see Figure 11 below). Each group might need to be engaged in a particular aspect of carbon management. For example, the media need to be engaged in discussions around the use of paper, transport requirements, accommodation choices and catering. Suppliers will need to be consulted on environmental procurement standards and price expectations.

Athletes and team officials	*Broadcast*	*Olympic and Paralympic family*	*Genera public*
Marketing partners	*Technical officials*	*Press*	*Spectators*
Workforce	*Delivery partners*	*Suppliers*	*Wider society*

Figure 11. Stakeholder groups for the London Games sustainability strategy

Any stakeholder group should clearly understand its roles and responsibilities. The focus here is on constituting a technical advisory group (or TAG) to provide input into the carbon management process.

London 2012 was the first WCE to formalise the constitution of a carbon TAG although there were previous examples of informal partnerships around carbon management.

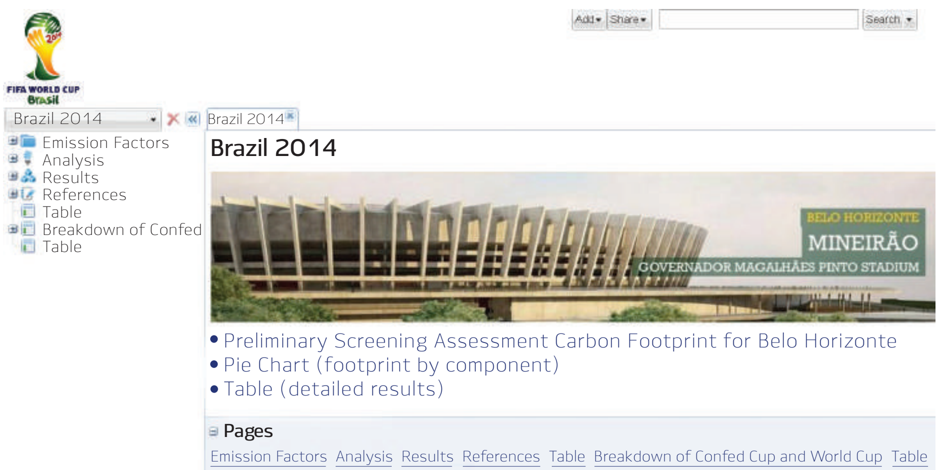
The roles and responsibilities need to cover:

- *objectives*
- *remit*
- *membership*
- *modus operandi and powers*
- *confidentiality*
- *communication protocol*
- *expected time commitment*

Carbon Footprint Tools

The use of carbon footprinting software can make the complex and time-consuming job of analysis, sharing and reporting data a little easier. The use of tools also helps with consistency, transparency and quality assurance.

Footprinter™ has been used on events including the 34th America's Cup, Sochi 2014 and the Brazil 2014 FIFA World Cup (see Footprinter screen shot below).



5. Reduction Opportunities

Overview[24]

The Global Energy Assessment (GEA)[25] analyzed a large set of energy transition scenarios that were consistent with the need to keep the planet within the 2°C target. The GEA found that limiting energy demand, electrifying the transport sector, significantly expanding carbon capture and storage (CCS) and increasing renewable energy production were the most critical measures. Global assessments, such as UNEP's "The Emissions Gap Report",[26] shows that emission reduction opportunities vary significantly by sector. Those sectors which have the greatest potential to deliver reductions include the power sector, industry, transport, buildings, and forestry (see Table 3).

This provides a useful context when deciding on the priorities for a WCE reduction and compensation strategy. In particular, stakeholders should consider how legacy projects might tackle the sectors with the highest GHG reduction potential.

Sector	*Emission reduction potential in 2020 (GtCO2-e)*
Power sector	*2.2 - 3.9*
Industry	*1.5 - 4.6*
Transport (incl.shipping and aviation)	*1.7 - 2.5*
Buildings	*1.4 - 2.9*
Forestry	*1.3 - 4.2*
Agriculture	*1.1 – 4.3*
Waste	*around 0.8*
Total (Full range)	*10 – 23*
Total	*17 +/- 3*

Table 3. Sectoral GHG emission reduction potential in 2020 compared to BaU, at marginal costs below 50 to 100 US$/tCO2-e, either explicitly or implicitly

24 Contributed by Margarita Dyubanova (Independent Consultant)
25 http://www.globalenergyassessment.org/
26 http://www.unep.org/publications/ebooks/emissionsgapreport/

Comparison of the mitigation technologies by the level of engagement, related costs and GHG emission reduction potential is presented below (Table 4).

	Low cost GHG emission reduction low Minor engagement	*Medium cost GHG emission reduction medium Medium engagement*	*High cost GHG emission reduction high Major engagement*
Transportation/ Land use zoning	*High occupancy vehicle lanes; smart commute; car pool networks; car share Natural gas vehicles Bus rapid transit On road bike lanes; bike share*	*Financial penalties for car use (e.g. tolls, congestion charge) Incentives for use of low emission vehicles Light rail transit Segregated bike lanes*	*Pedestrianization of city centres*
Buildings	*Building energy retrofits Green roof Energy star buildings*	*Improved building operations Renewable electricity (PV) or renewable heating/ cooling technologies*	*Demolition and reconstruction with high energy efficiency green buildings*
Energy		*District energy systems Borehole or aquifer thermal storage*	*Combined heat and power plants*
Solid waste	*Landfill methane capture Vacuum collection of solid waste*	*Solid waste gasification*	*Increased recycling Greening supply chains*
Water / waste water	*Reduced demand through low flush toilets or low flow shower heads*	*Reduced demand through grey water systems*	*Anaerobic waste water treatment plants*
Food / carbon sequestration	*Planting of urban forestry*	*Residential scale urban agriculture (in CO_2 enriched greenhouses)*	*Industrial scale agriculture (in CO_2 enriched greenhouses)*

Table 4. Mitigation technologies, level of engagement, costs, and GHG emission reduction potential (Adjusted from Kennedy, 2009c[27] and STAP, 2012[28])

[27] Kennedy, C. A., Ramaswami, A., Carney, S., and Dhakal, S. (2009a). Greenhouse gas emission baselines for global cities and metropolitan regions. World Bank's Fifth Urban Research Symposium. Marseille, France. Available at: http://siteresources.worldbank.org/INTURBANDEVELOPMENT/Resources/ 336387-1256566800920/6505269-1268260567624/ KennedyComm.pdf

[28] STAP (2012). Climate Change: A Scientific Assessment for the GEF. A STAP Information Document by N.H. Ravindranath, R.E. H. Sims, D. Ürge-Vorsatz, M. Beerepoot, R. K. Chaturvedi, and L. Neretin. Global Environment Facility, Washington, DC.

The remainder of this section considers reduction opportunities and case studies within the key areas that are most relevant to the staging of world class events of transportation, buildings and energy.

Low Carbon Building[29]

Introduction

Often, the largest environmental impact of a world class event is the development and ongoing operation of the buildings constructed to support the event. Very specific approaches must be crafted to address common types of buildings, such as athlete dormitories, hotels, office and mixed-use facilities, while different ones must be used for specialty venues for sporting events. In addition, different strategies must be used for new buildings compared with existing facilities. Given the goal of net-zero carbon impact of the Olympics, our focus in this chapter will be on the basic design and analytical process strategies for moving buildings toward to this vital objective.

To Build or Not to Build

The first question any sustainable strategy must ask is "do we need it"? Generally, the most sustainable facility is the one that is not built and that upgrading an existing facility is the preferred approach. Many games have adopted demountable buildings instead of permanent facilities, which for certain kinds of projects make sense. For other types of new or existing venues, installing temporary, modular heating or cooling capacity for the larger crowds expected for the Games might be a preferred approach.

[29] Contributed by Rob Watson, CEO & Chief Scientist, ECON Group

Integrative Design Process (IDP)

According to the Market Transformation to Sustainability Guideline Standard for Whole System Integration Process,[30] IDP is "A discovery process optimising the elements that comprise all building projects and their interrelationships across increasingly larger fields in the service of efficient and effective use of resources." Below we outline the "discovery process" of integrating energy efficiency and sustainability across multiple building systems. The integrative design process designs technology out of a project, rather than layering on green features to standard systems. As a first step, building loads are minimised and then they are met efficiently.

Five Rules for Sustainability Success

LEED Founder, Rob Watson shares five rules for success in a green building:

- *Start Early*
- *Discard Old Thinking and "Rules of Thumb"*
- *Establish a Firm Green Goal*
- *Adopt a Reasonable Budget*
- *Don't Sacrifice the Green Goal or the Budget*

Start Early

In an Integrative Design Process, there is a tremendous amount of investment early on in developing sustainability strategies that are integral to the design of the building. Energy efficiency and sustainability are addressed through multi-disciplinary and multi-perspective teams that work together intensively and during this time evaluate everything through an integrated value-engineering prism. By the end of schematic design, most of the major issues are resolved, which shortens the Design Development and Construction Drawing

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30 MTS 2012:1 Integrative Process (IP)© - ANSI Consensus National Standard Guide© - Design and Construction of Sustainable Buildings and Communities. Available at: http://webstore.ansi.org/RecordDetail.aspx?sku=MTS+2012%3a1

phases. Similarly, the Bidding & Negotiation process is shortened because key team members such, as the General Contractor, are brought on early in the IDP.

This is in contrast with typical linear design practice where the architect puts the initial design together relatively quickly and in isolation. Then, other various disciplines layer their solutions in an incremental and often disjointed manner through the DD and CD phases. Because things are not thought through early on, the Linear Design process generally results in a flurry of value engineering at the end of the project that often results in a significant compromise in the sustainability features with little to show for it in the final budget.

Discard Old Thinking

Rules of thumb can be helpful for making basic evaluations of whether a strategy is 'in the ballpark' of reasonableness. Unfortunately, many rules of thumb in building system design and operations in lighting and HVAC (heating, ventilation and air conditioning) are relics of the 1950s and 1960s. Couple this with siloed design and operations practices and it almost inevitably leads to over-design, excess capital expenditure, poorly functioning systems and ongoing energy waste. One frequent example of old thinking is not doing energy modeling, or doing it only after the project is completed in order to verify savings estimates or to submit the project for certification. This is exactly the wrong way to do it. Energy modeling is the most efficient and cost-effective way to evaluate different energy strategies at the beginning of the design process. Building simulations can become more sophisticated as the design becomes more refined, but the evaluation of major strategies can and should be done very early on.

Establish a Firm Green Goal

Having a clear target is an excellent way to focus the diverse talents necessary to deliver a green building. This is why having a mandatory Olympic Green Building Standard is key to reducing the environmental footprint of these events. Once a minimum target is established for Olympic projects, venue developers and their design and engineering

teams or venue owners and their operating teams know what to aim for, which is crucial for success in most types of endeavors, with sustainable building being no exception.

Adopt a reasonable budget

The perception is that green buildings cost significantly more than conventional buildings, but market data does not bear this out. Rather than the 15-20 percent price premium typically assumed for green features, studies have shown that typical extra costs range from negative first cost for very experienced green teams to ½ of a percent to 5 percent for more average experienced teams. This range of extra costs depends upon building type and degree of greenness. This is where "reasonable" comes in. It will be extremely difficult, for example, to achieve a LEED Platinum or an BREEAM Outstanding certification for less than 2 percent extra cost; therefore, a reasonable budget would reflect this fact. In an existing building, starting early is key to implementing low-cost and no-cost measures during the normal facility maintenance process to move the building toward sustainability. Once these measure are implemented, it can be ascertained whether achieving the project's green targets require capital investment.

Don't Sacrifice the Green Goal or the Budget

Often there is point in the green design process where there is a perceived crisis when the budget and the green goal are conflicting. Then, one of two things happens. Either the project decides that green is "too expensive" and gives up the goal or decides that the green goal will be achieved regardless of the cost. Both of these impulses are incorrect (and generally avoided with an integrative design process) where the cost and sustainability factors are weighed from the beginning and evaluated through sophisticated simulation tools.

General Low-Carbon Strategies for Different Building Types

While there are many sub-types of buildings, we have identified five principal building types typically constructed and operated for Olympic

events. While the Integrated Design Process (IDP) described above will yield the specific efficiency measures for the building type and climate, some basic strategies are addressed in Table 5 below. A presumption is that the measures listed below have been evaluated against other options and have been found to be cost-effective and appropriate for the type of building and climate.

An important legacy of the Integrative Design Process is a Calibrated Operational Model that can be used to evaluate the energy performance of a venue compared to its design ideal. Once the model has been developed during the new or building upgrade design process, it can be further calibrated according to the actual operational and occupancy parameters of the building once it is in use. Having a calibrated model will be the best way to benchmark the actual performance of the venues or other buildings. This is particularly true for unique and complex buildings such as sporting facilities, which are generally their own best comparison.

Although it is not emphasised in the table, installing renewable energy systems is a very visible and appealing strategy, even though the carbon reduction per dollar invested is well below energy efficiency strategies. Where available, purchasing renewable energy either directly or through Renewable Energy Credits is another way to offset carbon emissions from Olympic facilities.

Building type	*HVAC*	*Lighting*	*Envelope*	*Controls*	*Equipment*
Residential/ Hotel	*D: Higher efficiency and smaller sized for the improved shell & lighting. O: Re-commission HVAC system; air balancing; variable speed drives; high efficiency pump & fan upgrades.*	*D: High efficiency fluorescent for area with LEDs for accent. O: LED for incandescent and refrigerated cases. De-lamping reflector retrofits for fluorescents.*	*D: Beyond minimum code insulation and windows. O: Infiltration reduction; install window film; insulating curtains.*	*D: Key cards that control room energy. O: Occupancy sensors in intermittently occupied rooms. Update BMS sequence of operation.*	*D: Utilize waste heat from boilers or compressors for water heating. O: Upgrade seals on refrigeration equipment; low-flow showerheads.*

Building type	HVAC	Lighting	Envelope	Controls	Equipment
Indoor Stadiums	D: Displacement ventilation strategy and recirculation; Evaporative and desiccant temperature and humidity control; radiant strategies in cold climates O: Re-commission HVAC system; air balancing; variable speed drives; high efficiency pump and fan upgrades.	D: New multi-temperature LEDs for competition area; Day lighting and high efficiency fluorescent for other uses. O: LED for incandescent & outdoor lighting. De-lamping reflector retrofits for fluorescents.	D: Reflective and low-emissivity barriers in hot climate; Cold climates, use additional insulation. O: High albedo roofing material. Radiant barriers in the ceiling and walls. Infiltration/ leak control.	D: Demand-controlled ventilation for HVAC & occupancy control for regularly occupied spaces. O: Continuous HVAC fault detection. Occupancy sensors in light occupancy rooms. Update BMS seq. of operations; improve key sensors.	D: Utilize waste heat from boilers or compressors for water heating. O: Upgrade food service equipment in concessions; low-flow showerheads.
Outdoor Stadiums	D: Natural ventilation strategies for stands. Air curtains for luxury boxes. Radiant strategies for cold weather areas. O: Recommission HVAC system; air balancing; variable speed drives; high effic. pump & fan upgrades	D: New multi-temperature LEDs for competition area; Day lighting and high efficiency fluorescent for other uses. Light colored surfaces for corridors and passageways. O: Light colored surfaces for corridors and passageways.	D: on admin. & luxury boxes: Reflective and low-emissivity barriers in hot climate; Cold climates, use additional insulation. O: Low-emissivity or energy-efficiency film on luxury box windows. Reflective roofs for admin. parts of the stadium.	D: Time clocks for concession and maintenance lighting. Install BMS with analytics O: Adopt low-power partial lighting load strategies for post event cleanup.	D: Efficient food service appliances for concessions. O: Water-efficient on-site laundry; solar thermal for hot water.
Office/ Mixed Use	D: Smaller, Higher COP Chiller; Displacement & demand-controlled ventilation where appropriate; Evaporative cooling in dryer climates. O: Air balancing; upgrade air filters; Re-commission chillers; VSDs for pumps/fans	D: Task-ambient lighting; reflective surfaces; >100 lumens/Watt lighting systems O: LED for recessed lighting. Delamping + reflector retrofits with super T-8 fluorescents or LEDs;	D: More envelope and window insulation in cold climates; more mass in warm climates. On windows: emphasize U/K-factor in cold; SHGC in warm, VT everywhere. O: Apply low-e or energy efficient window film.	D: Day lighting and/or occupancy sensors as appropriate. Continuous fault detection of HVAC. O: Recommission BMS sequence of operations and improve key sensors.	

Building type	HVAC	Lighting	Envelope	Controls	Equipment
Transportation Facilities	D: Displacement ventilation strategy and recirculation; Evaporative and desiccant temp. and humid control; radiant strategies in cold climates. O: Improved filtration; VSDs on chillers, pumps & fans.	D: Day lighting and high efficiency high-bay fluorescents for concourses. LEDs for outdoor areas; O: Replace HIDs with fluorescents or LEDs as appropriate.	D: Low-e and thermally-resistant windows; reflective roofing. O: Apply low-e or energy efficient window film. Add radiant barrier and/or insulation as appropriate.	D: Demand-controlled ventilation; occupancy and day lighting sensors where appropriate. Install BMS with analytics. O: Occupancy sensors or daylight controls as approp; outdoor time clocks for lighting.	D: Install demand-controlled elevators and escalators. O: Install demand-controls for elevators and escalators.

Table 5. Key Design (D) and Operational (O) Energy Efficiency Strategies for Major Building Types

Legacy Strategies

Regardless of whether buildings are new or existing, having a good measurement and verification system in place will be crucial for managing the ongoing efficiency of the buildings after the Games end. Sustainable operations plans should be adopted for all facilities as part of the Olympic Green Building Standard.

Recommendation for an Olympic Green Building Standard

Construction and evaluation of venues should be treated with the same rigor and consistency with which Olympic sporting events are evaluated.

Just as there are rules governing all aspects of sporting competition-from the quality and nature of the physical characteristics of the field of competition to the specific definitions of competitive categories and the impact of external variables such as wind—so should there be mandatory rules governing the environmental performance of the venues that are constructed and operated for Olympic venues.

It is important to develop and apply a specific set of sustainable construction and operational criteria to all new facilities built and existing facilities upgraded for use during Olympic events. Pursuing these criteria would be certifiable under either BREEAM or LEED and all venues above a certain floor area—to be determined—would be required to certify in accordance with one of these international standards as chosen by either the host committee or the venue developer.

BREEAM

BREEAM[31] addresses the environmental performance of buildings across nine environmental and social categories (Table 6), plus a section on Innovation:

1. Management	*4. Transport*	*7. Waste*
2. Health & Wellbeing	*5. Water*	*8. Land Use and Ecology*
3. Energy	*6. Materials*	*9. Pollution*

Table 6. Environmental Impact Categories in BREEAM

BREEAM has four levels of certification covering the following building types and standards (Table 7).

1. New Construction	*5. International*
2. Domestic Refurbishment	*4. In-use (Existing Buildings)*
3. Communities	*6. Bespoke*[32]

Table 7. Principal Rating Systems in BREEAM

31 British Research Establishment Environmental Assessment Method (see http://www.breeam.org)

32 The Bespoke methodology creates environmental requirements tied to local norms and standards, as well as to particular building types.

The BREEAM Bespoke methodology was used for several major venues at the London 2012 Olympics[33] and is the one that was applied to the Sochi 2014 venues that were green certified.

The certification of BREEAM projects is handled by the network of BREEAM Assessors, some of which are local and some of which work internationally.

Advantages: Basing requirements on local regulations recognises the current state of the local industry and allows for easier adoption of the standard and presents a clear comparison of progress compared with current practice. For unique buildings and facility types, such as sporting venues, the Bespoke methodology provides a set of requirements that is clear and unambiguous for the owner and design teams. Local assessors know the local market.

Disadvantages: As the BREEAM Bespoke methodology is tailored to local regulations and/or specific building types, improvements and performance are relative, not absolute—certified projects might not achieve minimum compliance in other locales. With a relative standard, it is not possible to compare the performance of certified buildings across countries. Because the methodology works with individual projects, uptake and market transformation can be difficult due to a lack of involvement by the local industry. Assessment being vested in individual firms can result in varying interpretations of the requirements.

[33] Legacy venues certified include Olympic Stadium, Aquatics Centre, Velodrome, Media Centre, Eton Manor and the Handball Arena.

LEED

LEED[34] addresses the environmental performance of buildings across seven main environmental categories,[35] plus a section on Innovation & Regional Priority:

1. Integrative Process (V4)	*5. Energy Efficiency*
2. Location and Transportation (V4)	*6. Materials and Resources*
3. Sustainable Sites	*7. Indoor Environmental Quality*
4. Water Efficiency	

Table 8. Environmental Impact Categories in LEED

LEED has six main standards (Table 9).

1. New Construction	*4. Commercial Interiors*
2. Existing Buildings	*5. Neighborhood Development*
3. Core and Shell	*6. Homes*

Table 9. Principal Rating Systems in LEED

LEED was the certification standard used for the Vancouver Olympics and the Olympic Village at the Beijing Olympics used this standard, as well as several World Cup 2014 venues in Brazil. Currently, there are 18 major US sporting venues that are LEED Certified, 10 to the New Construction standard and 8 to the Existing Building standard, with another 8 venues registered in the system. There are also eight building-type standards (Table 10) that adapt the principal standards to the specific requirements of the listed building type, as well as address environmental issues unique to the building types.

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34 Leadership in Energy and Environmental Design (http://www.usgbc.org/leed)
35 Currently, LEED has five credit categories, with two being added in Version 4, which is being released widely in 2014.

1. Campus & Multiple Buildings	*5. Mid-Rise Multifamily*
2. Health Care	*6. Data Centers (V4)*
3. Retail	*7. Hospitality (V4)*
4. Schools	*8. Warehouses & Distribution Centres (V4)*

Table 10. Specialized Building-Type Rating Systems in LEED

LEED uses a common baseline for energy and water efficiency that applies to all projects certified under a particular standard. The underlying standards of energy consumption are the same. Certification submittals are handled through a centralised, web-based platform.

Advantages: LEED is more of an absolute standard that uses a core performance benchmark for all similar buildings, regardless of location. Because of consistent standards and methodologies, the results between LEED buildings are comparable across entire building portfolios. This allows a common training and common platform for design and engineering teams and a consistent interpretation of the requirements. Central evaluation of the submittal packages ensures greater consistency in project.

Disadvantages: Because energy in LEED is benchmarked to the ASHRAE[36] and other US-based standards, local designers must become familiar with a different and complex set of requirements that are only in English. In addition, although LEED has specific standards for eight building types, sporting venues are not included. These building types must interpret the general requirements from the New or Existing Building standards.

36 American Society of Heating, Refrigerating and Air-Conditioning Engineers

Developing an Olympic Green Construction Standard

The scope of an Olympic Green Construction Standard should cover the basic environmental impact categories found in the BREEAM and LEED standards (shown in Tables 6 and 8) with both design and operational requirements. The design portion of the standard should emphasise the lifecycle performance of the measures, while the operational portion should emphasise activities held prior to and during an event.

Criteria should be specific enough to give explicit direction to venue developers, designers and operators about expected performance requirements, while being general enough to be interpreted across BREEAM and LEED. The Olympic Standard also should be an absolute performance standard that uses identical requirements for similar buildings and similar climate zones.[37]

The Olympic Green Construction and Operation Standard would develop specific requirements to cover the following five building types:

- *Outdoor Stadium*
- *Indoor Stadium*
- *Hotel/Dormitory/Residential Buildings*
- *Office/Mixed-Use Buildings*
- *Transportation Facilities*

Energy Efficiency and Zero Carbon Assessment

There are three possible options for determining energy consumption and benchmarking carbon emissions for Olympic projects.

- *Asset Rating*
- *Operational Rating*
- *Calibrated Asset Operations Rating*

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[37] This varies from the BREEAM Bespoke standard, which is a customized standard that is benchmarked relative to local standards and construction practices. While this approach has many benefits, this type of localization is not allowed in international sporting competition and should not be followed in standardizing the environmental performance of Olympic venues.

The International Organisation for Standardisation issued the first version of its standard on Energy Management System, ISO 50001, in June 2011. It requires the use of Energy Performance Indicators, or EPIs, to track whether the complying organisation is on track in meeting goals of continual improvement in energy performance.[38] Following a common framework allows Olympic facilities to be analyzed through a common framework for measuring energy management effectiveness in the future and establish a foundation for compliance with ISO 50001.

Goldstein and colleagues describe three different "Energy Performance Indictors" or EPIs that can provide the necessary structure to assess Olympic venue energy performance on a comparable basis. These Energy Performance Indicators are as follows:[39]

Option 1, the Asset EPI or Asset Rating, is based on modeled energy use with uniform conditions of climate, schedules, plug loads, occupancy and energy management between set baseline parameters and the final design elements.

The Asset Rating answers the question: "How efficient is this building compared to minimum code?" Asset Ratings are analogous to energy consumption ratings for appliances or fuel economy ratings for automobiles.The energy performance guideline in the Olympic Green Building Standard would set a level of improvement over an established baseline—we recommend the ASHRAE 90.1-2010 standard due to its extensive technical development and its use as a baseline standard for both LEED and BREEAM. The baseline standard would be complemented by a set of modeling guidelines to establish consistency in inputs and outputs.

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38 David B. Goldstein, Natural Resources Defense Council Aimee McKane, Lawrence Berkeley National Laboratory Deann Desai, Georgia Institute of Technology, ISO 50001: Energy Management Systems: A driver for continual improvement of energy performance, 2011 ACEEE Summer Study on Energy Efficiency in Buildings

39 Goldstein, D, Eley, C, Three Types of Energy Indices for Buildings, (and Why Fixed Energy Budgets Should Not Be One of Them) 2012. Submitted to Energy and Buildings

Option 2, the Operational EPI or Operational Rating, is based on metered or measured energy use. The Operational Rating takes account not only of the physical characteristics of the building but also how it is operated.

The Operational Rating answers the question "How well is this building being managed compared with similar buildings?" This is similar to the "Energy Passport" which was developed by Russian building scientist, late Dr. Yurij Matrosov of NISSF.[40] An Operational Rating is generally used to benchmark existing building energy consumption relative to peer buildings. The most well-known Operational Rating system is the Energy Star program of the United States, but the BCA Green Mark in Singapore and the EU Energy Performance of Buildings Directive (EPBD) are similar. A challenge for this type of rating benchmark is having an adequate database to make meaningful comparisons.

The Calibrated O&M Index (Option 3) represents the ratio of actual energy consumption as measured at the meter to the predicted energy performance from an energy model, similar to the ones used to determine an Asset Rating. One difference between the Asset Rating and Calibrated O&M models is that the Calibrated O&M model has been adjusted to reflect the actual physical and operating conditions of the building, rather than standardised assumptions (see Table 11).

The Calibrated O&M Index answers the question: "How well is this building being managed based on actual conditions and building design potential?" This EPI would be used for unique, complex buildings that are not effectively evaluated using cross-facility comparisons.

[40] Yuri A. Matrosov, Research Institute for Building Physics (NIISF) of the Russian Academy of Architect and Building Science

Supporting Development and Implementation of a new Standard

Many technical efforts of this nature are done by volunteer professionals who seek to contribute to an interesting and worthwhile cause. However, these volunteers must be supported by capable technical and administrative staff that can “regulate the ordinary to free the creative” of the volunteers.

There are tens of thousands of accredited green building professionals across the globe with the experience and knowledge necessary to support the design, construction and operation of such facilities.

1. BREEAM Assessor List[41]
2. LEED Accredited Professional List[42]

Organizations such as the Green Sports Alliance[43] also can provide peer-to-peer guidance toward sustainable design and operations.

Financial Impacts of a Green Olympic Standard

Often, people are concerned that committing to green buildings requires extra cost, but global experience is that when green is a core condition of the project and that this commitment is known from the beginning, the design team can deliver the project for a very modest increment above a conventional construction budget (1-2%), and sometimes less. There are many ways of delivering a green project that do not impact the total budget - rather, green represents a different allocation of costs than a conventional project.

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[41] http://www.greenbooklive.com/search/scheme.jsp?id=214
[42] https://ssl12.cyzap.net/gbcicertonline/onlinedirectory/
[43] www.greensportsalliance.org

National and Regional Green Building Standards

Beside the global green building certification standards of LEED (Projects in over 120 countries) and BREEAM (Projects in over 50 countries), there are many national green building certification systems being used. The ten that cover the largest national or regional markets are presented here:

CASBEE—Japan *(http://www.ibec.or.jp/CASBEE/english/overviewE.htm)*

CEDBIK—Turkey *(http://www.cedbik.org/)*

DGNB—Germany *(http://www.dgnb.de/de/)*

Green Mark—Singapore
(http://www.bca.gov.sg/GreenMark/green_mark_buildings.html)

Green Star—Australia, New Zealand, South Africa
(http://www.gbca.org.au/green-star/)

Greenship—Indonesia *(http://www.gbcindonesia.org/)*

GRIHA—India *(http://www.grihaindia.org/)*

Pearl—UAE *(http://www.estidama.org/pearl-rating-system-v10.aspx)*

SBTool—Portugal, Czechoslovakia *(http://iisbe.org/sbtool-2012)*

Three Star—China
(http://esci-ksp.org/?project=chinas-three-star-building-rating-system)

During the preparation of the Olympic Games in Sochi, SC "Olimpstroy" jointly with the Ministry of Natural Resources and Environment of the Russian Federation, and other organizations, developed a new National Green Building Standard.

Project Type	Size	Method	Notes
Residential/ Hotel	<15,000 m^2	Option 1: Operational Rating required unless pursuing international green certification, which would involve Option 2; Option 2: Calibrated O&M Index, optional	We are recommending Option 2—Operational Rating for smaller projects, since they may not wish to conduct the modeling required for Option 3. However, there may be smaller projects that are seeking BREEAM certification that are already modeling, in which case Option 2 would enable them to ensure that their savings persist over time.
Residential/ Hotel	>15,000 m^2	Option 2: Calibrated O&M Index Option 1: Operational Rating	Larger projects should be required to pursue Option 2, since the savings can be substantial. In addition to modeling, large venues should be required to post their energy use online to begin establishing a national green label.
Indoor Stadiums	Any	Option 2: Calibrated O&M Index Temporary facilities: normalized energy use reporting for IOC	Indoor sports venues, especially ice venues, are too complex for meaningful comparison based solely on facility energy use. If the facility will only be used temporarily for the games, they should track their energy use during the games as normalized by attendance, floor area, events and weather.
Outdoor Stadiums	Any	Option 2: Calibrated O&M Index Temporary facilities: normalized energy use reporting for IOC	Outdoor sports venues are too unique for meaningful comparison based solely on facility energy use. If the facility will only be used temporarily for the games, they should track their energy use during the games as normalized by attendance, floor area, events and weather and report it to the IOC.
Office/Mixed	>15,000 m^2	Option 2: Calibrated O&M Index	Larger projects should pursue Option 2, since the savings can be substantial. This will be an important building type to demonstrate the modeling and benchmarking process for the broader goal of greening buildings in the host country. In addition to modeling, large venues should be required to post their energy use online to begin establishing a national green label.
Transport Venues	>15,000 m^2	Option 2: Calibrated O&M Index	Larger projects should pursue Option 2, since the savings can be substantial. As unique, complex structures to build and operate, the most appropriate baseline for transportation venues is the engineering optimum as represented by a calibrated simulation.

Table 11. Application of Energy Benchmarking approaches to different venue types

Renewable energy technologies[44]

Overview [45]

Renewable energy (RE) is a form of energy that can be replenished on a human life timescale and includes several sources: wind power, solar energy, hydropower, biomass, biofuels, and geothermal energy. RE is characterised by predominantly up-front capital costs with low short-term rates of return; however, in the long-term, they have low fuel and operating costs. The Global Energy Assessment analysis[46] has indicated that a significant increase in RE technologies is technically feasible, would give high overall benefits, and is a relatively low cost energy transition development route. Therefore, investment in RE at WCE is encouraged.

This chapter outlines promising RE technologies that can be used at WCE, their costs and mitigation potentials, and also discusses policy measures that, in many countries, could result in more rapid deployment.

At the global level, the share of RE as a proportion of total global primary energy still remains low (when traditional biomass is excluded); however, the share of energy supply attributable to RE in a growing number of countries and regions is rapidly rising. The recently published REN21 "Renewables: Global Status Report" (2013) highlights some positive trends in many regions:

- *In China, wind power generation has increased more than power generation from coal and exceeded nuclear power output for the first time.*
- *Wind and solar power are achieving high levels of penetration in countries like Denmark and Italy, which in 2012 generated 30% of electricity from wind and 5.6% from solar PV respectively.*

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44 Contributed by Margarita Dyubanova (Independent Consultant)

45 The description of innovation status and potential of the technologies listed in this section is adapted from two reports: REN21 "Renewables: Global Status Report" (2013) and N.H. Ravindranath, R.E. H. Sims, D. Ürge-Vorsatz, M. Beerepoot, R. K. Chaturvedi, and L.Neretin. STAP (2012). "Climate Change: A Scientific Assessment for the GEF. A STAP Information Document". Global Environment Facility, Washington, DC

46 http://www.globalenergyassessment.org/

- *138 countries defined RE targets.*
- *Support policies are in place in 127 countries, with two thirds of these in developing countries and emerging economies.*

Renewable energy for power generation has increased rapidly over the past decade. This trend is due to improvement in technologies over the last 30 years, gradually reducing costs, and expansion of government policies in this area. The quantity of wind-powered electricity production grew by 27% per year from 2005 to 2010 and production of photovoltaic electricity grew by 49% per year in the same period.

The Special Report on Renewable Energy Sources and Climate Change Mitigation from the IPCC[47] provides the context for understanding the role of RE in climate mitigation. This one thousand-page report reviews 164 medium to long-term scenarios. The report presents four scenarios with the contribution of renewable energy sources to global electricity production, ranging from 21 to 38% in 2020. Other recently published scenarios suggest that the contribution of renewable energy sources to electricity production in 2020 could be 32%[48] or 33 to 38%.[49] The highest estimates would lead to an extra electricity production of 4000 TWh. This could result in an emission reduction potential of 1.5 – 2.5 $GtCO_2$-e.

Local city, town and rural district governments are often in a position to successfully encourage development of decentralised RE projects by their residents and businesses.[50] In many remote rural areas of

[47] IPCC (2013). The Special Report on Renewable Energy Sources and Climate Change Mitigation. Available at http://srren.ipcc-wg3.de/report

[48] Deng, Y.,Klaus, S., Cornelissen, S., ven der Leun,K.,and Blok,K.(2011).Pathway to a fully sustainable global energy system by 2050. Linkping_Electronic Conference Proceedings, Vol.57:34923496.Linköping, Sweden

[49] Krewitt, W., Teske, S., Pregger, T., Simon, S., Naegler, T., Schmid, S., Graus, W., Blomen, E., Baer, P., Urge-Vorsats, D., Rutovitz, J. and Atherton, A. (2010) Energy [R]evolution, A Sustainable World Energy Outlook, 3rd edition, Amsterdam, the Netherlands: Greenpeace International and Brussels, Belgium: The Netherlands and European Renewable Energy Council. Available at: http://www.greenpeace.org/international/en/campaigns/climate-change/energyrevolution/

[50] Cities, towns and renewable energy: Yes In My Front Yard. Paris: International Energy Agency.

developing countries and transition economies, these distributed generation and mini-grids, have a potential to replace imported fossil fuel based sources and promote self-reliance of communities, avoid high investment costs for transmission line infrastructure, and provide local benefits of jobs and improve health. The co-benefits resulting from the deployment of RE technologies include energy security, improved health, employment, training opportunities through capacity building, improved social cohesion of communities, increased mobility of people and freight, and local community pride and time savings.

RE can be used either directly to provide energy supplies on-site or indirectly as a result of being integrated into an existing conventional energy supply system, such as an electricity network.

Centralized renewable electricity systems

Over the years, electricity supply systems have been developed to be highly reliable while managing demand loads that vary over seconds, days, weeks, and years. These complex systems are continuously evolving to accommodate increasing shares of renewable energy generation.

Distributed electricity systems, also known as “smart grids” or “digital energy systems” is a modernised electrical grid that uses information and communications technology to gather information about the behaviours of suppliers and consumers, in an automated fashion to improve the efficiency, reliability, economics, and sustainability of the production and distribution of electricity.[51]

“Smart grids” are not yet clearly defined in the sector, but in essence can be either large- or small-scale systems (including generation plants, transmission and distribution lines, end-use appliances and the end-users) that have been optimised by using digital electronic controls. The system communicates continuously along the entire electricity delivery infrastructure in order to integrate a range of energy

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[51] U.S. Department of Energy. "Smart Grid / Department of Energy"

carriers, and maintain system balance at all times.[52]

Several small-scale demonstration smart-grids have been implemented, and the private sector (including large corporations such as Siemens,[53] Intel, Vodaphone and Mitsubishi) has shown a growing interest. International standards for some components, for examples, time-of-use meters, are under development.[54] Battery electric two-, three- and four-wheel vehicles are rapidly gaining popularity, and can also act as a storage component of RE systems. However, they only give significant GHG mitigation potential per km travelled when RE electricity is available for off-peak recharging.

Concentrated solar thermal power (CSP)

Total global CSP capacity increased by more than 60% to about 2,550 MW. Most of this capacity was added in Spain, which now accounts for more than three-fourths of the world's CSP capacity. About 1,300 MW was under construction by year's end in the United States. Elsewhere, more than 100 MW of capacity was operating, mostly in North Africa. The industry's interest is on the rise with investment expanding into Australia, Chile, China, India, the MENA region, and South Africa.

Parabolic trough is the most mature technology, and it continues to dominate the market, representing about 95% of facilities in operation at the end of 2011, and 75% of plants under construction by mid-2012.[55]

Towers/central receivers are becoming more common and accounted for 18% of plants under construction by mid-year, followed by Fresnel (6%) and parabolic dish technologies, which are still under development.

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52 Schock, R., Sims, R., Bull, S., Larsen, H., Likhachev, V., Nagano, K., Vuori, S., Yeager, K., & Zhou, L. (2012). Energy supply systems. In Global Energy Assessment: Toward a Sustainable Future. Cambridge: Cambridge University Press. Luxemburg: IIASA.

53 See for example http://www.energy.siemens.com/hq/en/energy-topics/smart-grid

54 See for example http://www.sisconet.com/cimservices.htm?gclid=CMG--oOo_qwCFQ2DpAodGRspRw

55 "Cost Drivers Fuel Technology Switch for Concentrated Solar," Renewable Energy Focus, July/August 2012, p. 42.

Some experts have expressed concern that the window of opportunity for CSP scale up is closing as solar PV prices continue to fall and utilities become more familiar with PV.[56] However, CSP has a number of characteristics that are expected to remain attractive to the users. These include CSP's ability to provide thermal storage, and thus able to compensate for the variability in renewables, and its ability to provide low-cost steam for existing power plants.[57]

Decentralized renewable energy systems

Decentralised RE-based power generation systems, including solar PV and wind power at the 5 to 500 kW scale, have high potential to meet the energy needs.

Photovoltaic solar (PV)

Total global operating capacity of solar PV reached 100 GW, led by Europe, with significant additions in Asia late in the year. Due to the falling prices, PV is expanding to new markets, from Africa and the MENA region to Asia and Latin America. The interest in community-owned and self-generation systems continued to grow in 2012, with increased number and scale of large PV projects. The world's first multi-megawatt projects came on line in 2011, and, by mid-2012, more than 100 plants with total capacity of 100 MW were operating in at least 20 countries worldwide.

The concentrating PV market is still comparatively small, but interest is increasing greatly due to higher efficiency levels in locations with high insolation and low moisture. By early 2013, about 90 plants in operation were larger than 30 MW, and some 400 had at least 10 MW of capacity.

Innovation and product differentiation have become increasingly important, and successful manufacturers have diversified both upstream and downstream, with many of them expanding into

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56 Joyce Laird, "Is CSP Still on Track," RenewableEnergyFocus.com, 26 June 2012
57 Fred Morse and Florian Klein, Abengoa Solar, Washington, DC and Madrid, personal communications with REN21, March 2012; Laird, op. cit. note 25

project development or building strategic partnerships.

The average price of crystalline silicon solar modules fell by 30% in 2012, while thin film prices dropped by about 20%. Installed system costs are also falling, although not as quickly, and they vary greatly across locations. Cell and module manufacturers struggled as extreme competition and decreases in prices and margins had spurred more industry consolidation, and several Chinese, European, and U.S. manufacturers went out of business. Thin film's share of global PV production declined further, with production down by 15% to 4.1 GW.

Figure 12. Small scale temporary solar PV providing cost-effective off-grid lighting at the 34th America's Cup (Source: Anthesis Consulting Group)

Wind power

The popularity of wind power is increasing with at least 44 countries adding a total of 45 GW of capacity (more than any other renewable technology), increasing globally by 19% to 283 GW. The leading market is in the United States, while China remains the leader in terms of total installed capacity. Due to the falling prices, wind power is expanding to new emerging markets. Almost 1.3 GW of capacity was added offshore (primarily in northern Europe), bringing the total to 5.4 GW in 13 countries. Worldwide, at least 730,000 small-scale turbines were operating at the end of 2011, totaling 576 MW (27% more in comparison with 2010). By the end of 2012, total wind power capacity was enough to meet at least 2.6–3% of global electricity consumption.

The industry stakeholders have been challenged by downward pressure on prices, combined with increased competition among turbine manufacturers, competition with low-cost gas in some markets, and reductions in policy support driven by economic austerity.There are two distinct markets: models with rated capacity below 10 kW, and those in the 10–500 kW range. In general, the market is evolving towards 50 kW and larger turbines because they are easier to finance.

Heating and cooling

The application of solar thermal heat pumps to provide energy for hot water, building space or high-temperature industrial processes is well understood by global practice.

Solar thermal heating and cooling

Solar space heating and cooling are gaining popularity, as well as solar thermal district heating, solar cooling, and process heat systems. Globally, the market share of systems that provide both water and space heating is about 4% and is rising, with installations in established markets in South America (Brazil, Mexico) and Asia (China, India, Japan). The industry continued to face challenges, particularly in Europe, and was marked by acquisitions and mergers among leading players, with rapid consolidation continuing in China. Automation of manufacturing

processes increased in 2012, with innovation spanning from adhesives to materials and beyond.

Solar thermal technologies contribute significantly to hot water production in many countries, space heating and cooling as well as industrial processes. In 2011, the world added nearly 51 GWth (more than 72 million m^2) of solar heat capacity, for a year-end total of 247 GWth. An estimated 49 GWth (>96%) of the market was glazed water systems and the rest was unglazed water systems for swimming pool heating, as well as unglazed and glazed air collector systems.

The global solar cooling market grew at an average annual rate exceeding 40% between 2004 and 2012, ending the period with about 1,000 solar cooling systems installed, mostly in Europe.

By the end of 2012, global solar thermal capacity reached an estimated 282 GWth for all collector types, with the capacity of glazed water collectors reaching an estimated 255 GWth. China and Europe shared about 90% of the world market and the overwhelming majority of total capacity.

Comparison of key renewable energy technologies

There has been an attempt to characterise and summarise RE technologies by cost and mitigation potential by 2050 (Table 12). However, there are many exceptions due to variations in specific local resources and costs.

Technology Present levels of supply	Present levelized cost range of energy ($/kWh). Future cost reduction potential by 2050	Resource variability Dispatchability for power generation. Typical capacity factor.	Mitigation potential by 2050	Technical potential Deployment potential by 2050. Mitigation potential in 2050 from displacing coal and gas plant mix. Most suitable regions
Electricity				
Solar PV 0.026 PWh	$0.08-0.90/kWh High.Numerous small scale installations and several grid connected plants operating at the 1-5 MW scale. Module costs continue to decline, but labour for installation costs can remain a constraint in OECD countries as can energy storage. Can compete in remote locations or with retail power prices. Could become more competitive with wholesale electricity prices in an increasing number of regions and countries by 2030.	Minutes. Low dispatchability. Capacity factor 10%-25%. Needs energy storage.	Low-medium. Small share of generation mix but growing slowly. Displacing small diesel-powered generation in rural areas. Building-integrated PV good.	>1200 EJ 1-1.5PWh (3.6-5.4 EJ) 600-900 $MtCO_2$ Lower latitude regions.
CSP 1.5 GW	$0.20-0.50/kWh High. Heat at > 150oC converted to electricity via heat engine and generator. Cost, demand for water, and land competition can be constraints. Future opportunities especially in low latitudes with high solar radiation levels (e.g. North Africa). With technology improvements potential investment cost reductions could be 30-40% in the next decade. Investment costs expected to decrease with scale up.	Hours. Partially dispatchable if coupled with thermal storage. Capacity factor 35-40%	Mitigation potential by 2050 Deployment just starting up so limited by 2030. Dependent on electricity generation source being displaced.	>300 EJ 0.5-1 PWh (1.8-3.6 EJ) 300-600 $MtCO_2$ Deserts and high latitudes.

Electricity (continued)				
Wind onshore: 0.25 PWh Offshore: 0.05 PWh	$0.04-23.kWh Low. Mature. Grid connected increasing in number and individual capacity with lower price per installed watt and improved reliability. Developments moving offshore due to landscape objections in spite of higher installation and maintenance costs. Medium. Small turbines off grid less mature and need storage.	Minutes. Low dispatchability. Typical capacity factor 20-40% onshore and 30-45% offshore but can reach 50% in good sites.	High. Recent rapid growth rate likely to continue.	Onshore: 20-125PWh Offshore: 4-35 PWH Onshore: 6-12 PWh Offshore: 1-4 PWh Onshore: 3500-8000 $MtCO_2$ Offshore: 600-3000 $MtCO_2$ Worldwide
Heat				
Solar thermal: 0.6 EJ	$5-200/GJ Medium. Upfront capital costs for solar water heaters higher than for electric or gas water heaters but average annual lifetime cost can be considerably lower.	Daily.	Medium.	>1500 EJ 2-3 EJ 200-300 $MtCO_2$ Worldwide
Transport				
Biofuels: 3.1 EJ (90bn l)	$3-50/GJ ($0.15-2.5/litre) High. Mature first generation biofuels (except sugar cane ethanol) not competitive without support at oil prices < $100/bbl. Novel advanced processes offer scope for cost reductions through improvements in efficiency and yield. May compete better with gasoline, diesel and first generation biofuels between 2030 and 2040.	Seasonal.	Low to medium.	~100 EJ 10-30 EJ 600-3000 $MtCO_2$ Worldwide

Table 12. Assessment of costs (shown for electricity (kWh) or as primary energy (GJ)), cost reduction potential by 2050, technical potential, deployment potential and mitigation potential by 2050 for a range of RE electricity and heat systems (based on IEA, 2011a, c, d and Fischedick et al., 2011; and adapted from STAP, 2012)

Low carbon transport [58]

Overview

Rapid urbanisation and expansion of transport systems will likely comprise the largest source of future growth of GHG emissions in developing countries and transition economies. The transport sector has the highest projected growth rate of greenhouse gas emissions and currently accounts for 13% of global greenhouse gas emissions.[59] The Global Transportation Energy and Climate Roadmap[60] estimates the emission reduction potential for the transport sector, including aviation and marine, in 2020 to be estimated at 1.7-2.5 GtCO_2-e. Low-carbon, or sustainable transport programs, also improve local air quality, reduce congestion, reduce travel time, and increase the number transport options.

Sustainable transport focuses on moving people rather than vehicles, thereby optimising efficiency, reducing demand, shifting transport modes, and improving efficiency of both individual vehicles and transport systems are essential.[61] For road vehicles, new fuels and fuel efficiency standards for petroleum fuels are important. In the case of air and rail transport, a combination of several smaller steps (including technological, systemic, and management improvements) can achieve at least 2% annual energy efficiency improvement.[62]

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58 Contributed by Margarita Dyubanova (Independent Consultant)
59 UNEP 2012. The Emissions Gap Report 2012. United Nations Environment Programme (UNEP), Nairobi
60 http://www.theicct.org/global-transportation-energy-and-climate-roadmap
61 STAP (2012). Climate Change: A Scientific Assessment for the GEF. A STAP Information Document by N.H. Ravindranath, R.E. H. Sims, D. Ürge-Vorsatz, M. Beerepoot, R. K. Chaturvedi, and L. Neretin. Global Environment Facility, Washington, DC.
62 Ribeiro, S. K., Dubeux, C., Figueroa, M. J., Hupe. J., Kobayashi, S., Melobretas, L. A., Thrasher, T., and Webb, S. (2012). Chapter 9: Energy End-Use: Transport. In N. Nakicenovic, T. Johansson (Eds.), Global Energy Assessment, Cambridge: Cambridge University Press.

Avoid – Shift - Improve Policies

A framework of "Avoid", "Shift" and "Improve" policies[63] and measures is increasingly being adopted by the countries. A variety of successful policies within these three categories have been in place for decades in countries around the world.[64] See Table 13.

"Avoid" policies have an overall aim of reducing or avoiding trips, thereby reducing the generation of travelled vehicle mileage and therefore greenhouse gas emissions. This policy option is especially effective in preventing growth in the use of private vehicles in emerging economies, where assessments predict an exponential increase in the numbers of private vehicles.

The following policy options are available:

- *Bus Rapid Transit (BRT)*
- *Bike Share Systems*
- *Rail-based Mass Transit*
- *Parking Management*
- *Intermodal freight System Management (for delivery trucks)*

"Shift" policies encourage transition to the lowest greenhouse gas emitting modes of transportation and discourage shifts from walking, cycling, and public transport to private vehicles. These policies create the environment that improves the quality of public transport and facilitates development of alternatives , which are of higher utility to users in comparison with private vehicles. High quality transport accessible to a large number of people is necessary.

Modal shifts have high potential to reduce the growth of transport-related GHG emissions. For example, air and road transport can be shifted to rail, water or intermodal transport. In cities, careful planning

[63] UNEP 2012. The Emissions Gap Report 2012. United Nations Environment Programme (UNEP), Nairobi

[64] Pucher, J. and Buehler, R. (2010) 'Walking and Cycling for Healthy Cities'. Built Environment 36 (4): 91-409.

of road systems and the development of infrastructure and facilities for non-motorised and public transport can reduce the growth of demand for private vehicles use.[65]

"Improve" policies aim at improving the energy efficiency of individual vehicles and fuels through the introduction of innovative technologies and policies, including vehicle performance standards, voluntary programs, fiscal mechanisms, low carbon and alternative fuels, financial subsidies for advanced vehicle technologies, fleet scrappage programmes, among others. The aim is to ensure that future vehicles and fuels are cleaner and to encourage the use of efficient vehicles.[66]

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65 STAP (2012). Climate Change: A Scientific Assessment for the GEF. A STAP Information Document by N.H. Ravindranath, R.E. H. Sims, D. Ürge-Vorsatz, M. Beerepoot, R. K. Chaturvedi, and L. Neretin. Global Environment Facility, Washington, DC.

66 Sakamoto, K., Dalkmann, H. and Palmer, D. (2010). A Paradigm Shift Towards Sustainable Low-Carbon Transport. Financing the Vision ASAP. New York, USA: Institute for Transportation and Development Policy. Available at: http://www.itdp.org/documents/A_Paradigm_Shift_toward_Sustainable_Transport.pdf

Promoting clean electric buses in Beijing Olympics (2008)

To encourage the use of lower-emission public transportation at the Beijing Olympics, the Global Environment Facility (GEF) and its partners funded a project that demonstrated electric buses that were powered solely by lithium-ion batteries. These buses use a rechargeable battery to power an electric motor and motor controller instead of a gasoline or diesel engine, and therefore result in minimal emissions.

A special outreach program raised awareness among athletes, the media, and the general public about global environmental issues and how individuals could help reduce their negative impact on the environment. As a result of the project, Beijing continued to use buses powered by lithium-ion batteries.

Lithium battery powered electric buses were introduced to serve the 2008 Beijing Olympic Games (Source: http://www.chinadaily.com.cn/)

At national level, China launched a "10 city, 1,000 buses" initiative to encourage the adoption and development of alternative fuel buses across the country. This initiative stimulated over ten of China's large cities, including Shanghai, Beijing, Chongqing, Shenzhen, Wuhan and Zhuzhou to put 1,000 alternative fuel vehicles over the next years. This program contributed to the national goal of having ten percent of China's domestic vehicles use low carbon emission technologies. Demonstration of fuel cell buses began in Beijing by operation of six fuel cell buses, with the pilot later extended to the Shanghai World Expo 2010.

	Mitigation option	Mitigation potential	Policy/regulatory/ institutional/financial arrangements to promote
Avoid: excessive travel demands	Preventing excessive demand Urban planning: smart zoning with mixed use zones E-services, telecommuting	High/ Medium	Fuel pricing; provision of alternatives; taxes on externalities; Zoning regulations Infrastructure, e-services
Avoid: too large vehicles	Prevent the shift to larger vehicles	High	Feebate programs, car weight taxes
Avoid: unnecessary fuel consumption	Better maintenance of vehicles	Medium	Educational programs; regulations on regular vehicle maintenance
Shift: modal shifts	Road and air freight to rail, shipping and intermodal transport. Air and road passenger transport to rail. Urban passenger transport to non-motorized transport. Clean and efficient two-wheelers and public transport. Bus rapid transport + light rail.	High	Provision of appropriate infrastructure and facilities for alternatives Access restrictions Usage proportional to road fees
Shift/Improve: new fuels	Hybrid and all-electric vehicles. Biofuels.	High	NiMH or Li-ion battery programs to substitute lead-acid batteries. Life cycle assessment of fuels before use
Improve: road transport	Increase fuel efficiency; Minimal idling losses; Regenerative braking; Efficient two-wheelers; Road system planning and optimization.	High	. Fuel efficiency standards + feebate programs; Technological specifications inspection and maintenance programs.
Improve: shipping	Slow steaming; Fleet planning.	High	Mandatory speed limits; Capacity building.

Table 13. Avoid, Shift and Improve transport options, their mitigation potential and policies to promote the option (adapted from STAP, 2012)

The Offsetting Alternative[67]

As it has been previously noted, the purchase of carbon credits is one option for compensating for an event's residual carbon footprint once efforts have been made to avoid and reduce emissions.

An Introduction to the world of carbon credits

The proliferation of different types of carbon credits, regulations and standards is complex, confusing and ever changing. It is best to consult an expert for the most up-to-date information. At the time of writing, there are two primary sources for credits; the compliance market (CERs or ERUs) and the voluntary market (usually VCS or GS).

The following glossary explains some key terms and acronyms.

CER: Certified Emission Reductions. A Kyoto Protocol unit equal to 1 metric ton of CO_2 equivalent.

CDM: Clean Development Mechanism. A mechanism under the Kyoto Protocol through which developed countries may finance greenhouse-gas emission reduction or removal projects in developing countries, and receive credits for doing so which they may apply to meeting mandatory limits on their own emissions.

CO_2 e: Carbon dioxide equivalents – a measure of the combined impact of a basket of GHG in terms of their impact on the environment.

ERU: Emission Reduction Unit (ERU) equates to an emission reduction of one ton of CO_2 equivalent. ERUs are generated by Joint Implementation projects.

GHG: Greenhouse gases. The atmospheric gases responsible for causing global warming and climate change. The major GHGs are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Less prevalent, but

67 Adapted from a report prepared for the UNDP by Eric Matalon (Independent Consultant).

very powerful, greenhouse gases are hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

GS: Gold Standard. A certification standard, developed by WWF, for carbon mitigation projects, recognised internationally.

Kyoto Protocol: An international agreement standing on its own, and requiring separate ratification by governments, but linked to the UNFCCC. The Kyoto Protocol, among other things, sets binding targets for the reduction of greenhouse-gas emissions by industrialised countries.

Kyoto mechanisms: Three procedures established under the Kyoto Protocol to increase the flexibility and reduce the costs of making greenhouse-gas emissions cuts. They are the Clean Development Mechanism, Emissions Trading and Joint Implementation.

REDD: Reducing Emissions from Deforestation & Degradation in developing countries.

Registries: Electronic databases that track and record all transactions under the Kyoto Protocol's greenhouse-gas emissions trading system (the “carbon market”) and under mechanisms such as the Clean Development Mechanism and Joint Implementation (“National Registries” for the compliance market). “Registries” may also refer to databases under the voluntary carbon market (Markit, CDC-Climat and NyseBlue).

VCS: Voluntary Carbon Standard - the world’s most widely used voluntary greenhouse gas (GHG) reduction program. Under VCS, projects are issued unique carbon credits known as Verified Carbon Units or VCUs. Each VCU represents a reduction or removal of one ton of carbon dioxide equivalent (CO_2-e).

Ensuring credible, robust carbon credits

Carbon credits vary widely in their cost and credibility. For robust, transparent and traceable carbon credits, it is important to consider many factors:

- *Compliance with standards. Currently, best practice is to procure CERs or ERUs from the compliance market and VCS or GS from the voluntary market.*
- *The registry. Procure carbon credits only through a credible registry (for example, Markit, Climate Action Reserve, American Carbon Registry or APX).*
- *The vintage. Ensure that credits are ex post credits verified and issued and not ex ante projects.*
- *The methodology. Ensure that the methodology used to verify the projects generating the carbon credits is widely accepted and credible.*
- *The project type. It is important to consider the nature and location of the project in terms of how it aligns with the communication aims and goals of the WCE. For example, whether the project delivers wider social benefits or supports other environmental imperatives - water conservation or wildlife protection, for instance. It is common for carbon credits of different projects to be assembled into "portfolios" to address a range of different social and environmental aspirations.*
- *The cost. The quality of carbon credits is generally reflected in the price. Lower cost credits should be viewed with suspicion.*

How to engage partners and sponsors

Engaging partners and sponsors in carbon reduction can and should be handled in the same manner as any other partnership arrangement. This can be undertaken directly by the WCE organising committee or indirectly through the appointment of a Carbon Offset Partner who will, in turn, seek to engage delivery partners, other sponsors and spectators in a wider carbon offset programme.

The more targeted an offset scheme is, the more closely it is related to the partners' or sponsors' business and their values, the easier it is to engage them. For example, an airline company is more likely to be interested in offsetting air travel; and a logistics partner is going to be more interested in offsetting the fuel used by their vehicles.

Any partnership agreement should indicate the following elements:

- *a general presentation of the event;*
- *a brief history of the hosting City or Region and their environmental plans and aspirations;*
- *background of the event organisers and their commitment to carbon reductions;*
- *event supporters, such as Government and private sector;*
- *existing environmental achievements, focusing on carbon, and future plans including a description of the legacy aspirations;*
- *the nature of any exclusivities or preferences around the provision of carbon credits.*

The 2010 Vancouver Winter Games pioneered the idea of an event-wide, central carbon offset fund generated through contributions from a range of stakeholders. The London 2012 Games took this further by appointing an official Carbon Offset Partner and sponsor, BP Target Neutral (see information box).

Travel carbon offset schemes have become a common practice beyond the WCE sector and are also popular when compensating for event-related travel. Little adaption is required to use the schemes applied by airlines, rail or coach operators.

The schemes can be voluntary or mandatory. That is, the price of the offsets can be embedded in a purchase price or be optional. Prices can also be fixed or variable. For example, the price of a branded t-shirt could include a "fixed levy" to cover the average cost of carbon offsetting an item of clothing or the levy could be variable according to the carbon impact of the item in question.

Possible schemes to consider include:

- *Air, train and coach travel:* a number of airlines already operate credible offsetting schemes on their booking sites such as EasyJet,[68] Continental Airlines,[69] Air Canada,[70] CheapTickets,[71] Virgin Australia,[72] Qantas[73] and Air France.[74] Most are optional and variable according to the length of the journey.
- *Accommodation:* these are less common than travel schemes but operate along similar lines. Guests at hotels can choose to offset their stay by purchasing carbon credits. Offset schemes are operated by brands such as the Hilton, Clarion and Mercure. Some hotels offset on behalf of guests but most schemes are voluntary and carry a fixed levy – for example, linked to a number of room nights or the class of a room.
- *Tickets:* event tickets provide an opportunity to promote and present several options to the spectator including the benefits of recycling. This can be combined with other communications and pledges to encourage wider behavior change.
- *Merchandise:* the range of merchandise means that it is usually only practical to consider mandatory, fixed levies on items. For example, the 34th America's Cup calculated the amount and type of clothing it would most likely sell and added a mandatory, fixed levy on to each item.

Figure 13 below summarizes the algorithm for engaging partners and sponsors as developed for Sochi 2014.

68 http://www.easyjet.com/en/environment/carbon_offsetting.html
69 http://www.continental.com/web/en-US/apps/booking/flight/searchRT.aspx
70 https://aircanada.zerofootprintoffsets.com/
71 http://www.cheaptickets.nl/en/flygreen.cfm
72 https://www.virginaustralia.com/public/system/carbon/index.htm
73 https://www.qantas.com.au/travel/airlines/offset-my-flight/global/en
74 http://corporate.airfrance.com/en/sustainable-development/co2-calculator/co2-calculator/

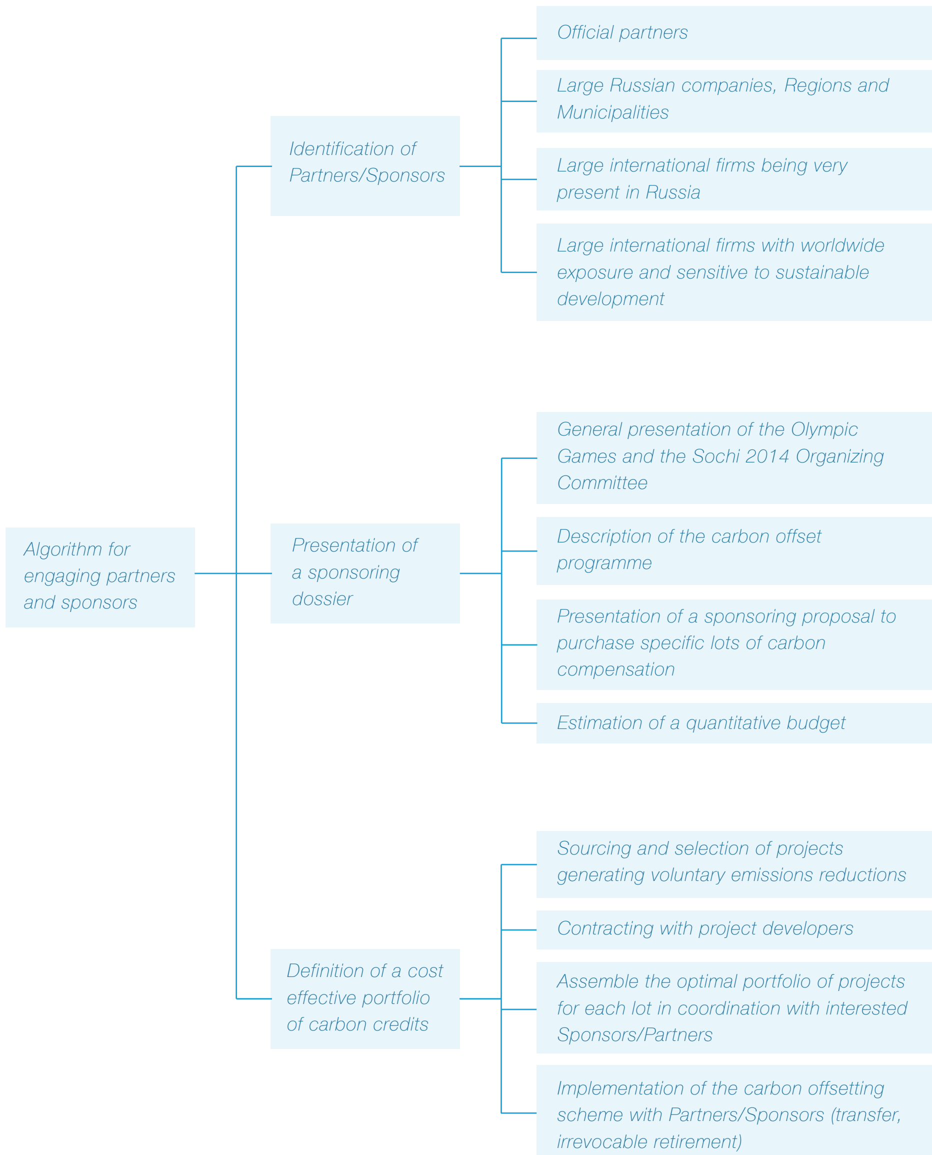

Figure 13.
Algorithmn for engaging partners and sponsors

Case Study: BP Target Neutral

BP Target Neutral was appointed as the official Carbon Offset Partner for London 2012. They developed a free, voluntary travel carbon offsetting scheme for spectators, as part of a larger reduction programme, which covered all modes of travel to the Olympics and Paralympic Games. To simplify the scheme, the levy was fixed by country of origin.

The scheme used high quality, voluntary market carbon credits. Spectators could sign up to the scheme online or register during the event. To incentivise signing up, visitors were offered a free photograph in front of the Olympic Stadium.

The scheme became the largest of its kind, offsetting over half a million journeys and over 100,000 tonnes of CO_2.

6. Case studies

A Green Sports Facility[75] [76]

Safeco Field is home to the Seattle Mariners (an American professional baseball team).

- *Location: Seattle, Washington began construction: March 8, 1997 opened: July 15, 1999*
- *Seating capacity: 47,860*
- *Venue uses: MLB games, amateur baseball events, collegiate football events, and corporate and political events.*
- *Annual event utilization: 125-150 stadium-level events per year*
- *Construction cost: $722 million (in 2012 dollars)*

Overview

In 2006 the Seattle Mariners set out to make the Safeco Field stadium's operations more efficient. Since then, the team has reduced its energy intensity at the ballpark by 25 percent and saved a total of nearly $2.2 million of energy costs, over $300,000 annually, and boasts the lowest energy intensity of all the Major League Baseball stadiums that participate in EPA's Energy Star program.

Figure 14. SafeCo Field (Source: Cacophony)

[75] Contributed by Rob Watson, CEO & Chief Scientist, ECON Group
[76] I am grateful to the Natural Resources Defense Council (NRDC) for their case study on the Mariners in the Game Changer report and Scott Jenkins and his facility team for updated data on their programs.

Vice President of Ballpark operations, Scott Jenkins explains, "Reducing your environmental impact is an opportunity to do the right thing as a business." But apart from cost savings, the Mariners see greening as a business opportunity that supports a triple bottom line, an opportunity to green the brand, which gives them the ability to sell to more people and build a deeper relationship with their customers.

Identifying the biggest environmental impacts

Through carbon footprint analysis the Mariners identified the biggest environmental impacts at the stadium, which were fan travel and the energy and water consumed in their buildings, these last two were the impacts over which the ballpark had the most influence. By devel oping a baseline of their current performance, the Mariners had actual metrics, which allowed them to target areas with the biggest cost savings opportunities, enabling them to set improvement goals and to make the business case for environmental initiatives at the stadium. They determined how much was being spent each day on energy and water and then set standards for energy reductions. Making the financial argument went hand in hand with reducing consumption.

Energy and Water

They set a $100,000 cost-savings goal for the first year, but actually reduced costs by $275,000, principally through natural gas savings. Initially these gains involved the lowest-hanging fruit:

- *better use of automation,*
- *better discipline in turning lights and equipment off when they are not used,*
- *low-cost measures like aerators on faucets, weatherstripping on doors,*
- *upgrade of some elements of control system.*

The next level of gains after the easy improvements may require some outside help, including engineering studies and investment strategies. Despite the higher up-front cost, these retrofits quickly paid for themselves. These improvements included:

- *retrofitting with low-flow urinals (which use 1 pint of water per flush, rather than 1 gallon),*
- *recommissioning all HVAC systems,*
- *upgrading controls and equipment,*
- *upgrading lights.*

Waste management

Waste diversion programs are a challenging, multiyear process, but the financial savings add up considerably. In 2012, the Mariners saved $125,000 in avoided landfill costs through their composting program.[77] Although such programs can often be justified on cost terms alone, the most valuable part of a recycling program is that it is a visible way to connect greening initiatives with the fan community. The Mariners engaged their fans and sponsors in their zero waste initiatives. Scott Jenkins explains: *"It's a natural place to start the conversation with your customers and employees. It's one of the few things that everybody participates in."*

When the Mariners began their recycling program, the stadium diverted about 12 percent of their waste from the landfill. The Mariners now boast an impressive diversion rate of 86 percent, but it wasn't easy getting there.

Making the switch to entirely compostable serviceware was particularly challenging. When the Mariners launched their program, initially there were not many product choices and it was expensive. The different performance characteristics, such as compostable service items are more susceptible to heat, required some adaptation. Since then, the marketplace has reacted; there are more suppliers, more types that you can buy, and the cost is coming reducing.

[77] The economics of sustainability will vary by location depending on the available infrastructure, so there some balancing considerations are required.

Diversion Rate Initial:	Activities
12%	• Recycling containers for Paper, cardboard, some cans & bottles
38%	• Increased recycling containers • Train Staff • Post-collection sorting
70%	• Compostable products for food service (cups, plates, flatware)
86%	• Eliminate garbage bins: recycling and composting only • Work with suppliers to make all products recyclable or compostable

Lessons from the field

Sustainability is a Process - Start Small and build up: *"You can't force change—it has to evolve",* - says Jenkins. *"You need to start small and celebrate those wins. It's a journey and you need to engage a lot of different stakeholders to make it work."*

Data collection drives Performance and helps target your efforts where you will get the most benefit: Keeping regular and consistent data on your facility's consumption highlights areas for improvement and cost savings and guides your environmental efforts accordingly.

Get the right people involved from your staff: Building a core green team of staff from different departments - engineering, security, food service and procurement - who are passionate about this work, is key to getting environmental initiatives off the ground. As you hire, integrate greening work into job descriptions.

Recognize the efforts of your Staff: Doing this gives staff the satisfaction of knowing they helped the facility succeed and they can feel good about what they do in the larger context of improving the bottom line and reducing environmental impact. Consider having top-performing staff recognized by star athletes.

Look for opportunities to establish partnership with local companies and organizations: Energy and water utilities, local design, engineering and contracting companies, food and supply and waste management companies all can be engaged to help a facility to achieve its goals.

Be Patient: Greening programs won't be successful overnight. *"You have to be willing to try things that might fail, learn from them and make adjustments,"* Jenkins advises. *"Choose your opportunities carefully and start small. Get a little success, learn from it and figure out a better way to do it, then look for the next opportunity."*

Sustainability is a business opportunity: Top 3 business opportunities: (1) green your brand, (2) reduce your costs, and (3) reduce your environmental impact. This gets support at the league level, the executive level, the ownership level, from the staff and from the fans. Although there is a lot of social momentum around sustainability, the biggest selling point is the business case.

The Mariner's key accomplishments

- *Through numerous energy efficiency efforts the Mariners saved approximately $2.2 million in utilities costs (electricity, natural gas, water and sewer) from 2006 to 2012 by reducing natural gas use by 44 percent, electricity use by 25 percent and water use by 24 percent.*
- *The team replaced its old scoreboard with a new LED model, which lowered annual electricity consumption by more than 90 percent (from 1.2 million kilowatt-hrs to 130,000 kilowatt-hrs) reducing costs by $50,000.*
- *Energy initiatives have resulted in an average annual energy savings of $298,500, with savings as high as $350,000, compared with 2006. Energy reductions have reduced carbon dioxide-equivalent emissions by 21.2 million pounds a year.*
- *The Mariners established zero waste goals, which increased waste diversion rates from 12 percent in 2006 to 86 percent in 2011, saving $125,000 in landfill costs in 2012 and reducing greenhouse gas emissions by 10.4 million pounds (CO_2-equivalent) from 2006 to 2011.*
- *The Mariners' purchasing policies prioritize greener products, including:*
    - *hand towels and toilet tissue made of 100 percent recycled fiber*

- *Office paper made of 100 percent post-consumer recycled fiber*
- *97 percent of all custodial supplies certified by third-party ecolabels.*

Fan Engagement Examples

Compost Trivia Game: *"Fans are asked an environmentally themed question near the beginning of the sporting match. The answers can be found at one of 16 Zero Waste Stations manned by volunteers working to help fans recycle and encourage them to play the game."* explains Jenkins. Later in the event, one lucky fan who has texted in the correct answer is awarded prize and an autographed ball.

Sustainable Saturday: The team gives away thousands of green products branded with a team star, so fans are motivated to undertake sustainable actions at home.

London 2012 Olympic Stadium: Reducing embodied carbon through efficient design[78]

Importance of embodied carbon

Embodied carbon emissions, those emissions related to the production, processing and transport of building materials, were a key consideration in the construction of the London 2012 Olympic Park. As the operational carbon emissions from buildings are reduced through energy efficiency measures, the embodied carbon emissions become more significant.

While no specific embodied carbon targets were set for London 2012, the drive to cut costs and build efficient structures led to significant carbon savings ranging from 9% to 38% depending on the project.

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[78] Adapted by the author from: http://learninglegacy.independent.gov.uk/publications/reducing-embodied-carbon-through-efficient-design.php

The Stadium

The Olympic Stadium was designed from the outset to be a flexible structure which would function as a centrepiece 80,000 seat stadium during the Games but could be converted to a permanent 25,000 seat facility afterwards.

The design incorporates a sunken concrete bowl – which seats 25,000 around the centre track, with the middle and upper stands supported on 40 metre long steel rakers. The use of bolted rather than welded steel, or concrete, makes deconstruction simpler for legacy use.

The partial roof consists of a fabric membrane extending 28 metres inwards around the entire stadium circumference. This is supported by a steel cable-net structure which also supports the lighting.

Despite some initial reservations, the concrete podium top was poured using a 100% recycled aggregate substitute. In addition, a reused gas pipe formed the ring beam for the stadium roof. This not only saved money but reduced project risk.The final design used around half the materials of the preliminary scheme and had a carbon footprint 38% lower.

Figure 15. London 2012 Olympic Stadium (Source: David Stubbs, London 2012)

Lessons learned

Several lessons were learned in a review of the various approaches used to reduce embodied carbon emissions in the Olympic Park.

Early injection of carbon targets into the design process - at every stage of design there is scope for improved material efficiency – many of the London 2012 construction projects saw major embodied carbon savings made in the detailed design stages. However, the earlier carbon emissions are prioritised, the greater the impact. Projects that write low carbon targets for materials into the design brief, encourage collaboration between the architect, engineer and contractor to explore and review efficient design options, and carry out detailed optimisation work during technical design, will invariably be lower in embodied carbon.

Set a clear brief for legacy – legacy considerations led to several different solutions: for some venues the Games and legacy specifications could be matched, resulting in a permanent venue (Velodrome and Handball Arena); for other venues downsizing after the Games was necessary to meet the legacy needs (Olympic Stadium and Aquatics Centre). Several permanent bridges were also replaced by lighter temporary bridges after considering the long-term infrastructure requirements; other bridges had temporary portions that were removed to make them narrower after the Games; for other venues the entire construction was temporary and was deconstructed after the Games (Basketball Arena, Hockey Centre, Water Polo).

Integrate functional requirements – a holistic design will allow multiple design requirements to be met by a single solution, so reducing the overall material requirements. For example, integrating the structural frame of a building with its thermal envelope (inner and outer skins) reduces the material required (as compared with separate systems). Examples include the F10 land bridge, which provides land access from Stratford City Centre to the Park, also forms part of the Aquatics Centre roof, leading to cost savings and environmental benefit.

Avoid over-specification – significant material and embodied carbon

savings were made at the Park by optimising the structural designs of the venues and infrastructure. This work typically occurred in the concept phase, by questioning what is the best solution, and in the detailed design phase, by matching specific loads with lean structural solutions. In some cases reducing the material demand required additional testing of the construction materials, to have confidence in the outcome. For example, the natural frequency of the Velodrome stand structure, which being multipurpose saved many tonnes of materials, was approximately 2.3 Hertz, well below the value of 3.5Hz recommended by the building codes. Detailed computer modelling and post-construction vibration tests were used to confirm that crowd dynamics would not be a problem in the finished buildings.

Landfill Methane Capture and Burning in Sochi Region[79 80]

Stimulated by the Sochi 2014 Olympics and Paralympic Games, a new landfill gas (LFG) capture and combustion facility was built according to the Resolution of the Government of the Russian Federation "About the construction of Olympic facilities and development of Sochi as a mountain resort" of December 29, 2007 No. 991 (item 169). This facility will provide lasting GHG reductions.

Methane, the second most abundant greenhouse gas after carbon dioxide, accounts for 14% of global greenhouse gas (GHG) emissions.

Methane is considered a "short-term climate forcer," meaning that it has a relatively short lifespan in the atmosphere, approximately 12 years. While methane is in the atmosphere for a shorter period of time and is emitted in smaller quantities than CO_2, its ability to trap heat in the atmosphere, which is called its "global warming potential,"

[79] Contributed by Vladimir Berdin (International Sustainable Energy Development Centre under auspices of UNESCO (ISEDC))

[80] The authors of the Handbook express gratitude for the Russian company SAFE TECHNOLOGIES (http://www.zaobt.ru/), Sankt-Petersburg, which build the LFG capture and burning system at the Adler landfill and provided the authors by the project information.

is 21 times greater than that of CO_2.

Methane is emitted during the production and transport of coal, natural gas, and oil. Methane emissions also result from livestock and other agricultural practices and by the decay of organic waste in municipal solid waste landfills.

Municipal solid waste landfills are the third-largest source of human-related methane emissions, accounting for approximately 17 percent of these emissions. At the same time methane emissions from landfills (landfill gas or LFG) represent a lost opportunity to capture and use a significant energy resource.

One successful example of LFG capture and combustion is in the region of Sochi at the Adler municipal solid waste landfill.

The facility is located on the right slope of the river "Small Herota", 4 km from where it joins the Black Sea. The landfill accepts waste from households, businesses and institutions within the City. The landfill has been operating for over 50 years. The landfill was capped in 2009 with layers of natural and synthetic materials.

Analysis of the LFG at Adler landfill shows that it contains methane (CH_4) - 40-60%, carbon dioxide (CO_2) - 40-50%, hydrogen – up to 10%, nitrogen – up to 10% and oxygen - up to 2%. Other trace gases do not exceed 2% by

The project activities included drilling of gas drainage wells, construction of gas collecting and storage system, condensate removal units, gas compressor station (Figure 16).

Figure 16 (left). Ground LFG collection equipment. A pipe for filtrate collection (right), a pipe for LFG collection (left)

Figure 17 (right): High temperature flame equipment

High temperature flame equipment was used to convert methane to carbon dioxide and to remove all other contaminants contained in LFG (Figure 17). While maintaining combustion temperatures above 1.000° C methane converts to carbon dioxide with an efficiency of 99.9% and all harmful impurities are neutralized. Module is in operation 24 hours a day.

Implementation of Adler landfill project will help to achieve significant GHG emissions for the period up to 2024. Results of baseline emissions (emissions which would have been in the absence of the project), expected project emissions (expected emissions after implementation of the project) and emission reductions related to the project, expressed in CO_2-equivalent, are presented in the Table 14 below. Expressing emissions in CO_2-equivalents reflects the full global warming potential.

Year	*Baseline GHG emissions, tonnes of CO_2-e*	*Project GHG emissions, tonnes of CO_2-e*	*Emission reductions, tonnes of CO_2-e*
2010	*15 847.0*	*2 786.2*	*13 060.8*
2011	*14 401.4*	*2 531.9*	*11 869.5*
2012	*13 139.1*	*2 312.0*	*10 827.0*
2013	*12 032.4*	*2 117.1*	*9 915.3*
2014	*11 058.3*	*1 948.1*	*9 110.2*
2015	*10 197.3*	*1 659.6*	*7 773.6*
2016	*9 433.2*	*1 659.6*	*7 773.6*
2017	*8 752.3*	*1 540.0*	*7 212.2*
2018	*8 142.9*	*1 432.7*	*6 710.1*
2019	*7 595.3*	*1 336.4*	*6 258.9*
2020	*7 101.3*	*1 249.3*	*5 852.0*
2021	*6 653.9*	*1 170.6*	*5 483.3*
2022	*6 247.1*	*1 099.0*	*5 148.1*
2023	*5 875.9*	*1 033.7*	*4 842.2*
2024	*5 536.1*	*973.9*	*4 562.2*
Total	*142 013.3*	*24 986.5*	*117 026.8*

Table 14. Adler landfill methane project emission reductions

Emission reductions will continue long after 2014, contributing to Sochi's Olympic legacy.

Energy Modelling at Sochi[81]

Energy simulation is a simple and inexpensive way to evaluate energy saving options during the design process, as well as the energy performance of the final building prior to occupancy.

Energy modeling is based on the physical attributes of buildings, such as wall areas, window areas, thermal conductance, air leakage, etc., combined with reported performance metrics from manufacturers, such as the efficiency of a boiler or the wattage of a motor. Modeling assures that when assessing energy consumption, building efficiency differences are not being confounded with differences in building operation.

When calculating annual energy use, assumptions are often required particularly if the building being modeled is not completely built or fully occupied. These assumptions include items such as zone temperature settings, occupancy or event schedules, types of events, plug loads, number of occupants, hot water loads, as well as schedules of operation for HVAC systems, lighting systems and other systems.

Because buildings are so complex, there are many possible ways to represent the various systems and technologies they contain. Thus, one potential problem with simulation is that modelers - without consistent guidance - can generate wildly different outcomes.

For this reason, EcoTech International (ETI, now ECON Group) adapted a simplified set of modeling guidelines from the COMNET professional society for the Sochi 2014 Winter Olympics.

The ETI Modeling Guidelines (EMG) cover general elements, such as establishing baselines, defining thermal zones and the parameters of the basic calculation procedure. In addition, there is guidance on HVAC sizing, Ventilation Requirements, Simulation Software Requirements and standardized tests of model integrity.

[81] Contributed by Rob Watson, CEO & Chief Scientist, ECON Group

The EMG has 11 chapters covering everything from Project Data to Cogeneration and Fuel cells. For each chapter element, the guidelines cover five elements:

1. *Applicability: which building systems and sub-systems the modeling guideline applies to.*

2. *Definition: a narrative, a numeric description or a formula description of equipment and/or input parameter being evaluated.*

3. *Units: what form the input parameter takes. This could be a list of measures, a ratio, a percentage, a number, etc.*

4. *Input Restrictions: this sets boundaries on the parameter in terms of the values and applicability. This forces the modeler to stay within normal ranges of values and only model equipment that is installed.*

5. *Baseline Rules: any parameters that must be modeled in the baseline.*

The modeling guidelines were applied to the energy simulation of the Hotel complex to house members of the International Olympic Committee (IOC). The modeling team found the document to be "useful methodological material, giving explanatory and detailed description of the scenario situations as applied to the construction of computational models of the analyzed buildings." The expert team also believes that the modeling guidelines, "significantly reduces the effort of experts during the Russian model of analysis for the purposes of the international environmental certification."

Although the ETI Modeling Guidelines for Olympic projects represent best practice in the field, the rules principally are geared for projects certifying under LEED using the ASHRAE 90.1-2007 standard. For this reason, teams that are modeling to BREEAM Bespoke or other systems need to verify and ensure that there is no conflict in the rules for modeling under these certification programs.

Transport Infrastructure in Sochi[82]

In addition to the Winter Games, the next few years will also see the City hosting the FIFA World Cup and the Formula 1 Grand Prix of Russia. Located on the coast of the Black Sea and the Caucasus Mountains, the city's subtropical climate and beautiful scenery make it a major national tourist destination. Every year more than 4m tourists visit the city.

Sochi's surrounding topographical limitations put a strain on the city's growth. The city has grown dramatically in the past years. No proper transport management system existed before the Winter Olympic Games as well as a synchronized line system with coordinated integrated bus and rail schedules. Crossings and junctions were not managed properly and caused numerous bottle necks due to poor traffic prioritization.

Cableways

By the beginning of the Olympic Games 14 cable car routes had been built and commissioned, including large passenger cableways, which start from the Imereti Valley and end at the finish area of ski resort "Rose Khutor."

With a capacity of 4,500 people per hour, these "cableways" provided a viable alternative to road building reducing the CO_2 emissions of transport.

The pre-existing public transport bus fleet was characterized by outdated buses and was not capable to cope with current and future transport demand in the region. Increasing traffic volume could not be managed during several periods throughout the day. One of the primary objectives of the Olympics was to leave a lasting legacy of efficient transport systems and knowledge to serve the city, region and nation for future events.After the Games, the city of Sochi aspires to be a world class tourist center.

As Sochi aspires to become a city of maximum mobility, the Municipality

82 Contributed by Margarita Dyubanova (Independent Consultant), Sergei Tambiev (UNEP/GEF Project) and Lev Averbukh (SC Olympstroy)

of Sochi was implemented fundamental changes in the form of parking management, traffic restrictions and intermodal public transport. Realizing these challenges, UNDP/GEF Project “Greening 2014 Sochi Olympics” commissioned Masterconcept Ltd. to study the region’s transport problems and propose alternative solutions.

The new public transport scheme designed and introduced in Sochi during Olympics 2014, reflected in Figure 18 below, was structured according to principles of an intermodal system, with interchanges among connecting lines and other transport modes. There are links of the railway lines with seven main coastal and mountain hubs (Sochi main station, Khosta, Matsesta, Adler, Olympic Park, Estosadok, Krasnaya Polyana) with feeder bus lines and ten links to the spine lines. Rail is used as a backbone of fast and reliable transport with hubs acting as effective interchange nodes.

Redesigned bus lines fed into the rail network and covered all population and business areas. The spine bus system operated from Sochi hub to Sochi Olympic Park, Krasnaya Polyana hub and Adler Airport. Between Sochi and Olympic Park there were feeder bus lines to connect all rail hubs to the area around. They were operating according to the timetable of the trains and spine buses, as well as the size of the catchment area.

Even though cycling was not allowed in the Olympic park during the Sochi-2014 Games due to safety regulations, new opportunities for bicycle use have been implemented within the territory of Imereti Valley which included marked up pathways, parking stands and sufficient lighting. Some of the venues obtained additional changing rooms and showers for the staff who use bicycles as delivery vehicles.

Bicycle routes were laid in proximity of the key Olympic venues as shown on the figure below as part of the overall travel plan. Inspired by the world’s recognized green standards, the implementation of new bicycle infrastructure has created Olympic legacy and contributed to carbon neutrality of the Olympics.[83]

[83] http://www.priroda.su/item/2665

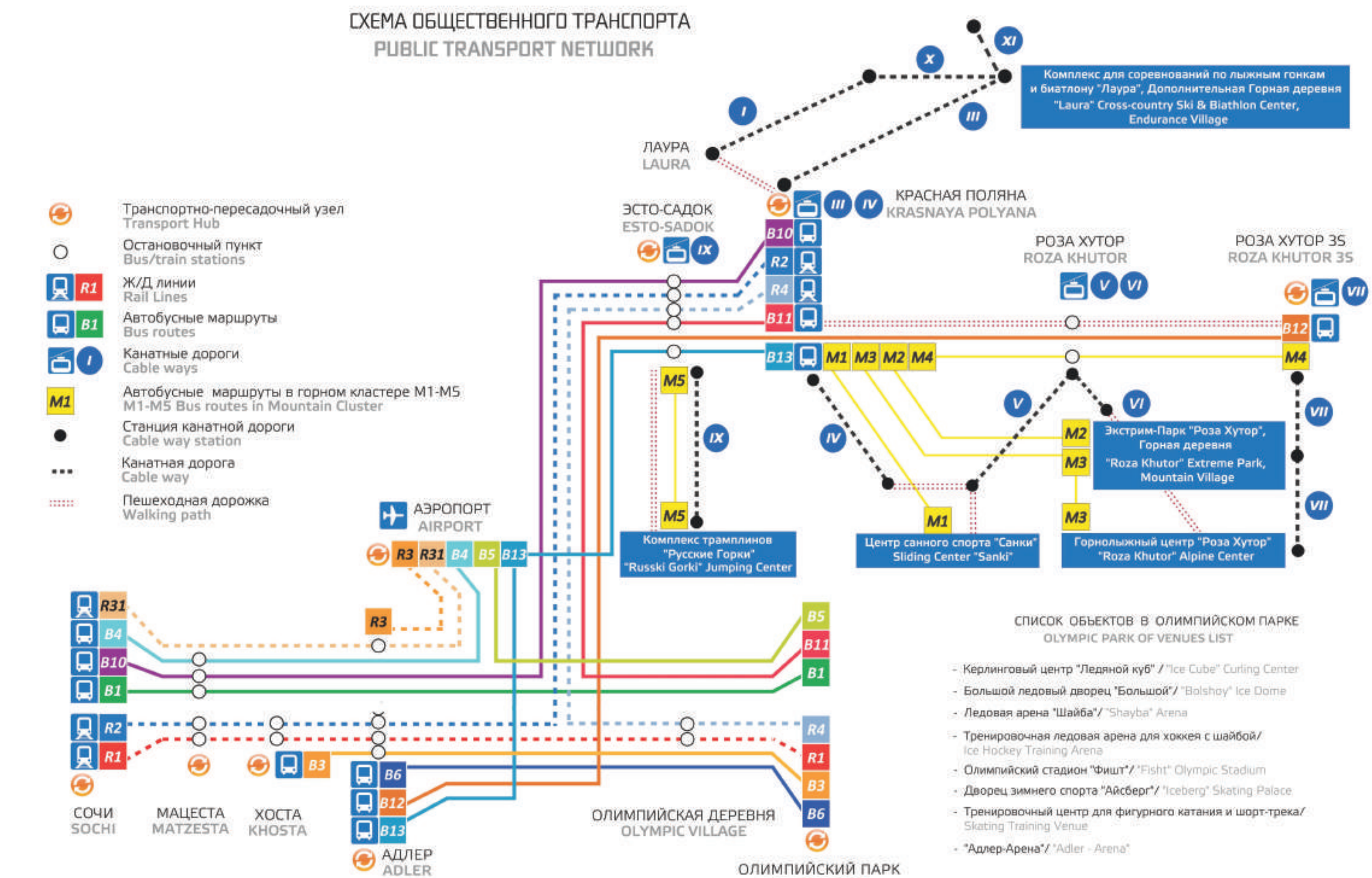

Figure 18. Integrated public transport line for Sochi 2014 (Source: Olympic Games Transport Directorate)

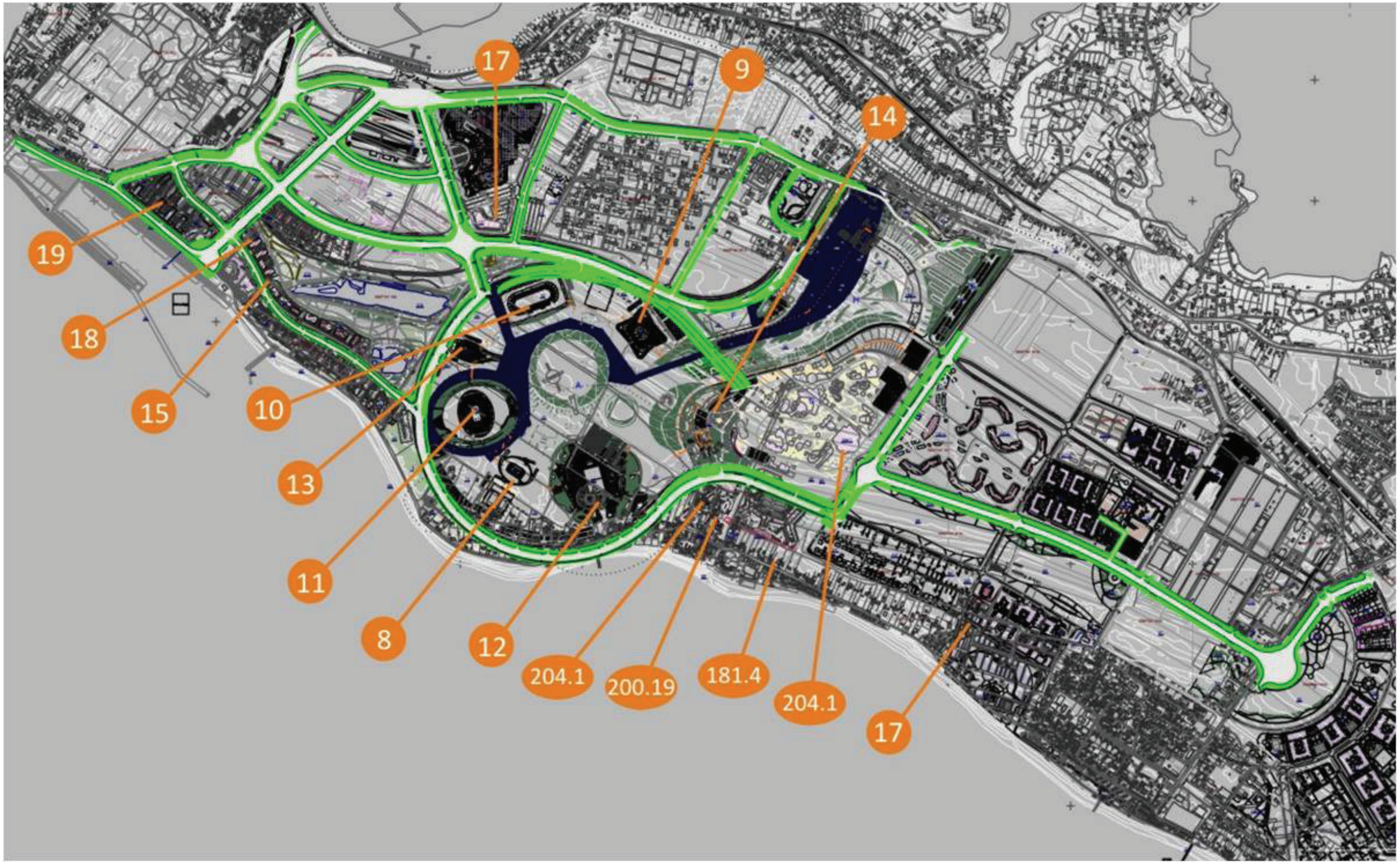

Figure 19. Cycling lanes scheme in Imereti Valley

Bolshoi Hockey Arena - BREEAM Assessment[84]

Figure 20. The Bolshoi Hockey Arena in Sochi

BREEAM

BREEAM (BRE'S Environmental Assessment Method) was first developed in the early 1990's to measure and enhance the environmental performance of buildings. Environmental performance is measured in a number of categories: management, energy, health and wellbeing, pollution, transport, land use and ecology, materials and water use. Credits are awarded in each area according to performance. A set of environmental weightings are applied enabling the credits to be added together to produce a single overall score. The building then receives a rating of Pass, Good, Very Good or Excellent (see Table 15).

Standard methods exist for a range of different building types and bespoke methods can be developed for any type of building in any location. A bespoke version, based on BREEAM Bespoke International 2008 (Issue 1), was used for the assessment of the Bolshoi Hockey Arena.

[84] Performed by C.Baagenholm (Buro Happold Ltd.)

Aims of BREEAM

- *To mitigate the impacts of buildings on the environment.*
- *To enable buildings to be recognised according to their environmental benefits.*
- *To provide a credible, environmental label for buildings.*
- *To stimulate demand for sustainable buildings.*

BREEAM development is overseen by an independent Sustainability Board, representing a wide cross-section of construction industry stakeholders.

The environmental weightings are as follows:

Issue Category	Issue Weighting
Management	12%
Health and Wellbeing	15%
Energy	19%
Transport	8%
Water	6%
Materials	12,5%
Waste	7,5%
Land Use and Ecology	10%
Pollution	10%

The scoring levels are as follows:

Score	Points
Unclassified	<30
Pass	≥30
Good	>45
Very Good	≥55
Excellent	≥70
Outstanding	≥85

Table 15. BREEAM environmental weighting and scoring levels

Figure 21. The Bolshoi Hockey Arena at night

Bolshoi Hockey Arena

The Bolshoi Hockey Arena is a 12,000 venue arena built for the Sochi Olympic Games. The venue will host all the major Hockey games during the Games and thereafter be converted into a multifunction arena facility able to hold ice hockey games, other sports and concerts. The total gross area is around 96,000 m^2. The design and main contractor was Mostovic.

Bolshoi Hockey Arena Interim Design Stage Assessment

Buro Happold was commissioned in 2011 by Mostovik to carry out a BREEAM assessment of the Bolshoi Large Ice Palace Hockey Arena in Sochi.

An Interim Design stage assessment has been carried out and a Very Good rating (60%) has been obtained. As a summary the following has been achieved in the different sections:

Management: environmentally friendly site management principles have been adhered to and thorough commissioning of the building. Public consultation has taken place and the outcome of the consultation adhered to.

Health and Wellbeing: efficient systems and controls ensure a pleasant indoor climate. Good natural daylight in concourse and office areas.

Energy: energy efficient systems and heat from a new local combined heat and power station.

Transport: good provision of public transport, limited parking spaces and bicycle parking ensures the venue will be accessed by other means than a private car.

Water: water saving taps and appliances ensure low water consumption.

Materials: procurement of environmentally preferable materials and protection of vulnerable areas in order to minimise maintenance and

material replacement.

Waste: efficient site waste management principles and provision of on site recycling during occupation.

Land use and Ecology: the ecological value of the site will be improved and a strategy for the long term survival put in place.

Pollution: water run-off into holding ponds and minimizing night time light pollution and noise attenuation.

The arena is currently undergoing the final Post Construction Review certification. Table 16 below shows a summary of the design stage score.

Building Performance by Section					
	Environmental weighting	Credits available	Credits achieved	% Achieved	Weighted Score
Management	12.00%	15	13	86.67	10.40
Health & Wellbeing	15.00%	9-14	6-7	49.18	7.38
Energy	19.00%	23-26	10-12	34.69	6.59
Transport	8.00%	14	13	92.86	7.43
Water	6.00%	8	4	50.00	3.00
Materials	12.50%	15	5	33.33	4.17
Waste	7.50%	7	6	85.71	6.43
Land Use & Ecology	10.00%	10	8	80.00	8.00
Pollution	10.00%	12-13	8	66.52	6.65
Total BREEAM Score					60.04

Table 16. A summary of the design stage score

General Information about the Bolshoi Hockey Arena	
Building	Sports stadium. 12,000 seater venue for Ice Hockey Matches duringthe Sochi Winter Olympics Games 2014. Thereafter, in Legacy Mode, a multifunction stadium facility for a number of different types of events including sports, concerts, events.
Site	Sochi Winter Olympics Coastal Cluster Site situated in the Imeretinskaya Lowland, Sochi. The site was previously low laying swampland. Following ecological surveys and State approved decisions, the existing topsoil was removed, the level of the site built-up (increased), building developed and the existing topsoil brought back.
Floor area	• Site Area - 52511.7 m^2 • Gross Area - Below Ground - 48869.0 m^2 • Gross Area - Above Ground - 47246.0 m^2 • Total Gross Area - 96115.0 m^2 • Construction Volume - 969893.83 cubm • Below Ground Construction Volume - 39095.2 cubm

Bolshoi Energy Demand Analysis[86]

Annual energy demand and use was estimated for the Bolshoi Ice Hockey Area with the aim of identifying energy and carbon reduction opportunities (see Figure 23).

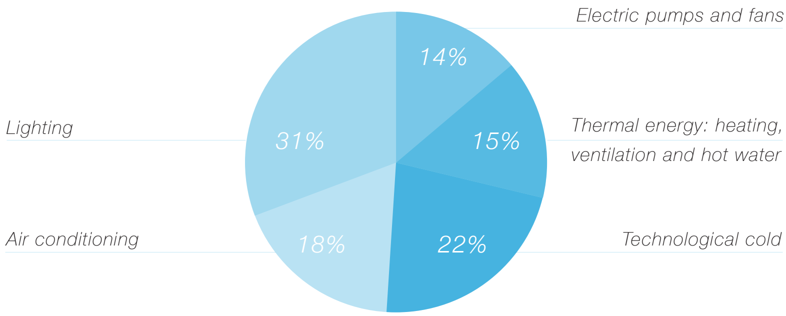

Figure 23. Estimated annual energy demand - Bolshoi Arena

To minimise energy use which maintaining a comfortable environment, areas of the Bolshoi Arena underwent three dimensional modeling of air and heat circulation. Based on modelled results a double-zone scheme of air exchange was chosen where air and heat streams circulate separately in the spectators' and the rink zones of the venue (figure 24). It has also become possible to operate and control the indoor climate parameters independently which saves up to 20-40% of the designed energy demand.

The illustrations below show conventional air circulation patterns compared with those for the Bolshoi dual-zone approach.

86 In the course of UNDP-GEF project "Greening 2014 Sochi Olympics: A Strategy and Action Plan for the Greening Legacy", the energy demand, and conservation options, for the Bolshoi Hockey Arena were assessed. This report has been adapted here as a case study (see http://greening-sochi2014.isedc-u.com/energoeffektivnost-i-planirovanie-energosberezheniya.html?id=55).

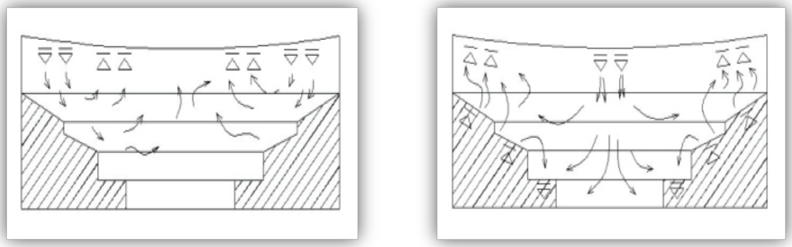

Figure 24. Conventional air circulation patterns (left) compared with those for the Bolshoi dual-zone approach (right).

The Bolshoi has been benchmarked against minimum requirements. The Arena is far more energy efficient in terms of both its thermal and electrical efficiency.

Measures to reduce energy demand included high levels of building insulation, compact building form, efficient heat recovery, and high efficiency pumps and vents.

The research also found that energy consumption is significantly affected by the pattern of building use. In order to maintain optimal building performance under different operational conditions, the venue is equipped with a contemporary building management (BMS) system. For instance, ventilation system adapts to air flow change and is automatically regulated. The air flow rate is adjustable with respect to CO_2 concentration in the tribune areas and the hall ductwork as well as according to CO_2 concentration in the ground floor car parking.

Overall, the design improvements are estimated to save a total of 4584 tonnes of CO_2 per annum made up of:

- up to 2601 tonnes CO_2 per year (thermal);
- up to 1983 tonnes CO_2 per year (electrical).

Development of Green Building Standard for Olympic facilities Sochi 2014[87]

Introduction

The Sochi 2014 bid book identified the need to deliver venues and infrastructure built to high environmental specifications.This resulted in the development of new, wide-ranging sustainable construction standards and guidelines.

The development of SED

As a first step, consultations were undertaken with experts and environmental authorities to understand the requirements of existing local and international green building codes and standards. Supplemental environmental demands and requirements (SED) were developed as a result of these discussions. SED is equivalent to other globally recognised green building standards, in particular, BREEAM (UK) and LEED (USA).

SED collects together, in one place, existing Russian environmental performance requirements with a focus on promoting sustainability.

It covers topics including resource conservation (heat, water, energy and so on), internal comfort, accessibility of facilities, waste handling and mitigation measures for reducing any negative impacts on the environment. The prescriptive part of SED contains 88 environmental performance criteria, divided into nine activity blocks and six building types.

Based on the SED, SC "Olympstroy" developed guidelines for team working (between client, developer and contractor) with the aim of setting out a clear process for delivering against SED targets. The guidelines also cover the method to be used for evidencing and assessing performance against the SED criteria at different phases

[87] Contributed by Gleb Vatletsov and Lev Averbukh (State Corporation on Construction of Olympic Venues “Olympstroy”).

Each Olympic venue had its own matrix of mandatory and optional performance criteria. The evidence for compliance was assessed by the appropriate SC "Olympstroy" qualified specialist. For each criteria, performance was assessed as either "criteria met", "criteria partially met", "evidence missing" or "criteria does not apply". Support comments were also provided by the expert assessors to encourage improvements. The ratings were undertaken using specially developed software. Assessments were subject to verification by an SC "Olympstroy" auditor.

Outcomes

The green standard is now integrated into SC "Olympstroy"'s Environment Management Systems (ISO 14001:2004) and is recommended for integration into EMS of counterparties involved in the Olympic program (i.e. investors, developers and main contractors). More than 70 specialists from more than 40 enterprises were trained to follow the standard. The standard became a tool to monitor and assess the activity of contractors for more than 200 objects which were to meet SED in the process of objects delivery.

The Olympic standard led to the adoption of innovative solutions which went beyond the prevailing Russian building practices. It has also inspired the formation of a national green assessors' institute and has provided a platform to disseminate best practice within the construction sector. It has also contributed to the development of the National green standard.

Adler Combined Heat and Power Station[88]

Introduction

The advanced gas-powered Adler combined heat and power station (CHP) is the largest federal energy facility. Built in readiness for the Sochi Winter Games and other future sporting events to be held in the city of Sochi, it started producing electricity and heat in January 2013. The plant is located in the Imereti Lowland area. (Figure 25)

Figure 25. Adler combined heat and power station

Environmental management of the works was in accordance with international standard ISO 14001:2004.

Description of Adler CHP

The Adler CHP has an installed capacity which exceeds 360 MW and was designed to provide sufficient power to meet more than one third of the projected peak power demand from Sochi during the Olympic Games.

The plant consists of two combined cycle gas turbine (CCGT) units. Each unit includes two gas turbines and one steam turbine. A heat recovery system ensures that waste heat from electricity generation is used to generate additional electricity before being released as lower grade heat.

[88] Contributed by A. Bespalov (State Corporation on Construction of Olympic Venues "Olympstroy")

Performance

The CHP plant is highly efficient. It achieves 52% efficiency and a 30% reduction in atmospheric emissions, when compared to other conventional steam turbines.

The results of independent calculations have demonstrated compliance with the relevant BREEAM criteria; confirmed dry NOx emissions ≤ 40 mg / kWh. According to the Institute of Global Climate and Ecology, Roshydromet and the Russian Academy of Sciences, the CO_2 emission factor for the Adler CHP is 0.43 tCO_2/MWh. Annually, 130.1 $ktCO_2$ were saved in 2013 with the expected savings to 2020 estimated at 568.8 $ktCO_2$.

The innovative cooling system comprises a closed-loop water supply system which leads to significant water savings. In addition, ultraviolet disinfection of waste water avoids the use of chlorine-containing reagents.

The 9.89 hectare site more closely resembles a neighbourhood park than a power complex with aesthetically pleasing buildings and extensive tree and shrub planting. The innovative plant is highly automated; only 15 people are needed to staff the equipment at any one time.

Olympic Park Railway Station – a public transport gateway for Sochi[89]

Figure 26. Sochi Olympic Park Railway Station (Source: Sochi 2014)

Overview

The Olympic Park railway station was designed and built between 2010 and 2013. The building ranges over seven floors, has a total area of 17,000m2 and is designed to handle up to 8,500 passengers per hour.

- *Architecture: LLC 'Architectural Bureau 'Studio A44'*
- *Chief Project Architect – Vasiliy Adolfovich Romantsev*
- *Chief Project Engineer – Lev Vladimirovich Gerstein*
- *Construction: OOO Management Company Transygstroi*

The Olympic Park Railway Station is the main gate to the 2014 Winter Olympiad in Sochi. It acts as a transport hub, servicing a number of Olympic facilities located in the Olympic Park and the Imereti Valley. In legacy, it will continue to provide a high quality public transport interchange for the area. It has been designed to be adaptable to future needs; some platform lengths can be varied and excess platforms can be disassembled as required.

A BREEAM assessment has been carried out and a Very Good rating (57.80 %) has been obtained for the venue.

[89] Contributed by Julia Shmeleva (Ecocentre IFPA)

Performance

Architecturally, the design is bold and includes a number of environmentally-friendly features. These include:

- *Connecting cycling paths and covered cycle racks.*
- *Low-level (40 lux) platform artificial lighting facilitated by a building design which maximizes natural light.*
- *Energy consumption sub-metering of functional zones as part of the integrated building management system (BMS). Covers external, platform and architectural lighting.*
- *The entire building is naturally ventilated.*
- *Use of photovoltaic panels to generate electricity from the sun.*
- *Use of energy efficient lighting and LEDs for architectural and platform illumination*
- *Low flush toilets (less than 4.5 litres), low flow taps (6 litres per minute and less) and infrared sensors in the urinals.*

Russian International Olympic University – educating for the future[90]

Overview

The Russian International Olympic University (RIOU) is the first university in the world dedicated to sport business education. It offers unique programs infused with Olympic values and experiences. RIOU's activities concentrate on training specialists in sports management for the Russian and international sports industry. It is located in the center of Sochi, in the heart of the Krasnodar region.

Figure 27. Russian International Olympic University (Source: Sochi 2014)

Design work started in 2010 – the construction was complete in 2013. The total area of the building is 16,400 m^2 spread over 15 floors and including education space, a recreational area and restaurant complex.

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[90] Contributed by Lev Averbukh

BREEAM assessment has been carried out and a Very Good rating (56,69%) has been obtained for the venue.

- *Architecture: TPO RESERVE LLC*
- *Construction: STROYPROFI-UG LLC*
- *BREEAM Type: Bespoke International 2008*
- *BREEAM assessor: PRP Architects*

Performance

The design and construction was guided by the following principles:

- *Attention to the natural environment;*
- *Delivery of a safe and comfortable working environment;*
- *The use of innovative solutions to create a resource efficient building*
- *Reduced consumption of resources: energy, water, construction materials;*
- *Minimization of negative environmental impacts during construction.*

Key carbon-saving features of the building include:

- *Use of energy-saving façade materials;*
- *Designing to maximize the use of natural light;*
- *Zoned, energy efficient, internal lighting to minimize energy use;*
- *Sub-metering of energy, water, heating consumption;*
- *Dual-flush toilets, low flow taps;*
- *Natural ventilation of all spaces;*
- *Separate collection of waste and recycling;*
- *Composting of food and garden waste.*

Carbon neutrality of Sochi 2014 as a catalyst for the development of carbon accounting in Russia[91]

The declared aim to make the Olympic and Paralympic Winter Games in Sochi 2014 'carbon neutral' attracted the attention of many governmental officials, business and expert communities in Russia. For many, it served as an introduction to modern approaches to the assessment of carbon footprints. There was particular interest from the construction sector including the operation of real estate and the development of new infrastructure.

The targeted analytical and information sharing activities instigated under the United Nations Development Programme (UNDP) and the Global Environment Facility (GEF) project "Greening 2014 Sochi Olympics: A Strategy and Action Plan for the Greening Legacy" (co-sponsored by the British Embassy Prosperity Fund) enabled staff and experts from the Ministries of Natural Resources and Economic Development, the Sochi 2014 Organizing Committee, and other stakeholders, to get enhanced knowledge of carbon management practices/ sustainability and carbon reporting.

The UNDP/GEF project has provided important substantive input and analysis of current trends and best practice in carbon reporting. Research found that there are over 50 national carbon reporting systems covering tens of thousands of businesses and organizations around the world. The main purpose of these systems is to create a consistent, efficient and economically effective system for regulating national greenhouse gas emissions.These systems operate in countries that make the largest contributions to global greenhouse gases emissions, such as China, the US, and countries of the EU.

Globally, there is a proliferation of carbon accounting systems – at the same time there are international efforts to standardize different approaches. In Russia some companies are reporting their carbon emissions but there are considerable gaps and deficiencies when compared with international best practice. Russia has not, to date,

[91] Contributed by Alexander Averchenkov, United Nations Development Programme

had a coherent national reporting system of carbon reporting and this is recognised as a significant gap in national climate change policy.

Based on the study findings, recommendations were made on how to improve the situation. The concept of carbon reporting in Russia has been significantly advanced, with widespread discussions by experts and governmental officials.

On 2nd April 2014 the Government of the Russian Federation approved an Action Plan to ensure the establishment of greenhouse gas emission targets – with the aim of ensuring that level of emissions of greenhouse gases by 2020 are not more than 75% from level of emissions of greenhouse gases in 1990. The Action Plan consists of three main sections. The first one prescribes measures for the development of a greenhouse gas accounting system, including carbon reporting for businesses and organizations (as an integral part of corporate non-financial reporting).

There are several UNDP/GEF project outputs that could usefully be used to inform the Action Plan implementation:

- *analysis of the international experience in the development of national systems for carbon reporting and the possibilities of its use in Russia;*
- *results from research, dialogues and consultations with governmental agencies, business and experts communities on development of non-financial reporting standards and standards on carbon management and carbon reporting;*
- *studied, adapted and applied methodology for determining the "carbon footprint" of activities, organizations, processes, products, including the Screening Assessment of the Carbon Footprint for Sochi 2014 Olympics;*
- *strategic paper on carbon offsetting options for Sochi 2014 Olympics;*
- *road map for gradual introduction of mandatory and voluntary non-financial carbon reporting for the companies with government participation.*

The commitment to make Sochi 2014 "Carbon neutral" facilitated the development and incorporation of carbon reporting and certification practices within the "green" construction industry in Russia and brought them closer to international standards. Experts proposed to put two different criteria of "green" construction standards in place: one reflecting the requirements to reduce CO_2 emissions and the other reflecting the positive impact of low-carbon construction materials.

One of the key issues in the development of a carbon reporting system for the design and construction of venues in Russia was the evidencing of emission reductions (avoided emissions). It should be, on the one hand, as simple as possible. On the other hand, it must accurately reflect national circumstances: the large size of the territory, the variety of climates and temperatures and the structure of regional fuel and energy balances. Claims for emissions reductions must be credible and defensible.

One important step in the development of carbon reporting in Russia is the creation of a national database of emission factors. These should differentiate between different types of activities and technologies that use raw materials and/or fuels and extend to include manufactured products and services. The database should be open and accessible to all parties concerned, periodically updated and verified by the relevant responsible authority and/or by independent experts.

Another important finding from the carbon analysis of the Sochi 2014 Olympic was around the concept of "embodied carbon". Estimating the lasting impact of an activity (such as the Games) involves considering the impact of international trade on carbon flows and how this is reflected in national and international reporting systems.

A study was conducted of the international carbon flows of embodied greenhouse gas emissions in Russia's products and services. The report highlights the importance of quantifying carbon flows both in to, and out of, the Russian economy.

The issue of embodied emissions is growing in importance as businesses and governments around the world take greater care to reduce their own environmental impact. This increases expectations for international suppliers to provide information on the environmental performance of their products. This can influence purchasing decisions. A particular focus of the report's analysis was on commodities, as these make up over three-quarters of Russia's embodied emissions, with detailed discussion on the aluminium and steel sectors.

Excessive embodied emissions can have negative trading impacts. For example, the carbon intensity of European Union steel is estimated at 1.3 tonnes of CO_2 per ton, whereas Russian steel is estimated at 1.7 tonnes CO_2 per tonne. This significant difference in embodied emissions is likely to drive buyers to select, all else being equal, the EU product. It also leaves Russian products more exposed to volatile and rising fuel and raw material prices.

Recommendations

This set of recommended has been made for the Russian government and business:

- *improve data quality and collection on greenhouse gas emissions across key sectors;*
- *give specific attention to the subject of measuring, reducing and reporting emissions associated with embodied carbon;*
- *work with key Russian companies and sectors to pilot methods to measure the embodied greenhouse gas emissions within their products, conducted following established and internationally recognised standards;*
- *introduce a full scheme for the measurement of embodied emissions following the pilot studies;*
- *develop a methodology and calculation tools to support the companies to measure and report in an accurate and consistent manner.*

Companies across Russia can take part in this challenge by releasing high-quality data. This is part of a global trend we are seeing where businesses are being far more transparent with their stakeholders. This trend, which is transforming supply chains, has the potential to boost Russia's export markets, reduce costs and reduce greenhouse gas emissions.

Carbon reduction in transport management[92]

Overview

Providing sustainable low carbon transport was a fundamental principle embedded into the London 2012 Games transport planning. The Olympic Delivery Authority (ODA) transport plan set out five key Games transport objectives for London 2012 to deliver, including the provision of frequent, reliable, friendly, inclusive, accessible, environmentally-friendly and simple transport for spectators and visitors from all around the UK and overseas.

Figure 28. Javelin Train (Source: London 2012)

Within the UK, the ODA aimed to enable almost 100 per cent of ticketed spectators to travel to the venues using public transport, or by walking or cycling through a combination of incentives, transport provision and restrictions.

For example, the Javelin® service was introduced to relieve the bottleneck that would otherwise occur for spectators accessing the Park. Long-distance coaches delivered visitors directly to the main London venues. No general parking was available at the main venues.

[92] http://learninglegacy.independent.gov.uk/publications/carbon-reduction-in-transport-management.php

Performance

Using existing travel patterns as the reference footprint, carbon reductions of just over 60% were achieved by shifting transport modes away from private car use and domestic flights towards rail, bus, coach and taxi services.

The remote coastal venue of Weymouth provides an interesting case study. Here the vast majority of visitors (88%) would usually have arrived by private car. For the Games, existing rail services were enhanced resulting in an estimated 77% carbon emissions reduction.

Lessons learned

Transport choices – lower carbon travel choices need to be incentivized by offering free or discounted travel. Overseas travel is difficult to manage –carbon offsetting provides perhaps the only mitigating option.

Planning – Demand management is key to delivering a low carbon event. Early transport modelling should include the measurement of carbon. This modelling should include not just peak flows, but also loading (how full the vehicle is), to best utilise spare capacity. Avoid over-provision.

Data – it is important that modelled and primary data distinguish between day trippers and long stayers as these will place different demands on the transport system. Data should not ignore non-ticketed spectators whose movements are less predictable and whose numbers are less certain.

Procuring low carbon goods and services

Figure 29. Core Principles of the LOCOG Sustainable Sourcing Code (Source: London 2012)

The London 2012 organizing committee (LOCOG) produced a carbon supplement to their Sustainable Sourcing Code[93] that provided guidance to suppliers on how to measure the carbon footprint of supplied goods and services.

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[93] http://learninglegacy.independent.gov.uk/publications/locog-guidelines-on-carbon-emissions-of-products-and-ser.php

This supplement not only raised awareness amongst suppliers of the important of reducing their carbon emissions but also directed them towards measurement methodologies and standards. A simple measurement spreadsheet was also provided for use by smaller suppliers unable to invest in a full product life cycle assessment.

A similar document was developed by the Russian States Corporation Olympstroy. Entitled “Environmental requirements for manufacturers (suppliers) of basic construction materials, goods, structures for Olympic venues”,[94] the document was issued to subcontractors and suppliers of Olympic venues in Sochi and aimed at increasing the use of green materials, products, structures, equipment, construction and finishing of the Olympic venues.

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[94] http://www.sc-os.ru/en/press/index.php?id_101=1423&afrom_101=01.05.2010&ato_101=31.10.2010

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Afterword

"People need to understand why decarbonisation is necessary. They need to know it is possible. And they need to see that cutting emissions can benefit economics and people's well-being."

Ban Ki-moon, United Nations Secretary.

Even such a good and useful thing as a book has a carbon footprint. Logging, paper production, transportation, printing, recycling or dumping - every part of book's life cycle is a potential source of greenhouse gas emissions that affect the climate.

The Russian Carbon Fund calculated the carbon footprint of this book in order to understand its impact on climate, prepare guidelines for publishers and estimate the number of trees that will be planted to eliminate carbon emissions related to the handbooks lifecycle.

Footprinting results:
The carbon footprint for the whole production run of handbook is 627.6 kg CO_2-e.

In order to minimize the carbon footprint of future editions of this handbook we recommend to implement the following actions:

- *Using FSC (Forest Stewardship Council) certified papers.*
- *Supporting the growth of renewable energy (i.e. wind) through the use of paper manufactured using wind power and other forms of renewable energy and efforts to offset carbon impacts associated with book production*
- *Increasing the use of low VOC (<2%) vegetable based inks and least toxic materials and processes available*
- *Reducing Impacts in the Office*
- *Reduce Waste and Maximize Efficiency*

In order to offset the carbon footprint of this handbook, the Russian Carbon Fund will plant 712 pines on degraded forest in the Moscow region in Autumn 2014. The trees will be managed and monitored by

the local forestry department. Thus Russian Carbon Fund officially assures the carbon neutrality of the handbook.

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Russian Carbon Fund officially assures the carbon neutrality of the handbook.