“Resource Efficient Building Services”

Ant Wilson
Director/AECOM Fellow
Building Engineering

10th September 2014
Resource-efficient building services make the best use of materials, water and energy over the lifecycle of the installed equipment.

“...essentially, about doing more with less...”
Hywel Davies, CIBSE

“...can represent savings at every step and reduce the burden on the world’s precious resources...”
Ant Wilson, AECOM
Building Services in A Typical City Office Building

BUILDING SERVICES REPRESENT:

- **2–12%** of the total embodied carbon of a typical building
- **35%** of the capital cost of a typical city office building
- **40–50%** of life cycle expenditure over a 30 year period
30 Year High for Greenhouse Gas Emissions
10 September 2014, source edie newsroom

The amount of greenhouse gases in the atmosphere reached a record high in 2013, propelled by a surge in levels of carbon dioxide which experts think the planet may struggle to deal with.

That's according to the World Meteorological Organisations' (WMO) annual Greenhouse Gas Bulletin which called for "concentrated international action against accelerating and potentially devastating climate change."

The report also said that C02 levels increased at the quickest rate since 1984, suggesting the while emissions are rising; the earth's ability to absorb the gas may also be declining.

Professor Dave Reay, chair in carbon management at the University of Edinburgh, told the Guardian newspaper: "Of particular concern is the indication that carbon storage in the world's forests and oceans may be faltering.

"So far these 'carbon sinks' have been locking away almost half of all the carbon dioxide we emit. If they begin to fail in the face of further warming then our chances of avoiding dangerous climate change become very slim indeed."

Related articles
Landlord goes green with Green Man Lane project
IPCC climate change report: averting catastrophe is eminently affordable
Planet likely to warm by 4C by 2100, scientists warn
Rising Population and Available Land per Person (Hectares)

RISING POPULATION
Hectares of available land per person

- 1900: 7.91
- 1950: 5.15
- 1987: 2.60
- 2005: 2.02
- 2050: 1.63
On a global scale, both population and the average per capita footprint have increased since 1961. However, the relative contribution of each to the overall increased Ecological Footprint is different in different regions. The available biocapacity per person nearly halved in the same time (Figure 5).

Since the 1970s, humanity’s annual demand on the natural world has exceeded what the Earth can renew each year. Similar to overdrawing a bank account, eventually the resources will be depleted. At current consumption rates some ecosystems will collapse even before the resource is completely gone.
## CO₂ Emissions per Person in Different Counties

<table>
<thead>
<tr>
<th></th>
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<tr>
<td><strong>Annex I</strong>*</td>
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## Sustainability and the Top Nations of the World

<table>
<thead>
<tr>
<th>Country</th>
<th>GDP (trillion current $)</th>
<th>Total final consumption (ktoe) (1,000 tonnes of oil equivalent)</th>
<th>Building consumption (ktoe)</th>
<th>Industrial consumption (ktoe)</th>
<th>Transport consumption (ktoe)</th>
<th>Population</th>
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<td>17,420</td>
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Sources: IEA 2014 (energy consumption data); World Bank 2013 (GDP and population data).
Sustainability is Key Driver for Resource Efficiency
Resource Efficiency

- Reduce
- Recycle
- Reuse
Ellen Macarthur and the Circular Economy

The Principles

New CEO announced at the Ellen MacArt...
Linear Economy Verses The Circular Economy

- Raw materials extraction
- Materials processing
- Components manufacture
- Products manufacture and off site assembly
- Building services design, supply and Installation
- Building services in use / facilities Management
- End of operational life
- Disposal

Flowchart:

1. Raw materials extraction -> Disposal
2. Materials processing -> End of operational life
3. Components manufacture -> Products manufacture and off site assembly
4. Products manufacture and off site assembly -> Building services design, supply and Installation
5. Building services design, supply and Installation -> Disposal
6. Disposal -> Materials processing
7. End of operational life -> Re-manufacture
8. Re-manufacture -> Repair, Upgrade and refurbish
9. Repair, Upgrade and refurbish -> Re-distribute and Re-use
10. Re-distribute and Re-use -> Components manufacture
11. Components manufacture -> Products manufacture and off site assembly
12. Products manufacture and off site assembly -> Building services design, supply and Installation

The Circular Economy - Restorative by Design

1. Hunting and fishing
2. Can take both post-harvest and post-consumer waste as an input

SOURCE: Ellen MacArthur Foundation circular economy team
Life Cycle Assessment

- Extraction
- Waste
- Transport
- Construction
- Reuse
- Use
- Maintenance
- Disposal
- Landfill
Resource Efficient Building Services

CIBSE and WRAP Join Forces
Industry gets to grips with resource efficiency

WRAP/CIBSE workshops reveal M&E best practice

A collaboration between CIBSE and the WRAP to reduce resource waste has identified industry initiatives that could lead to changes in the way that building services are designed and delivered.

CIBSE is working with WRAP to increase awareness of the opportunities and business benefits of resource efficiency. Aecom was appointed to run seven workshops and to develop technical guidance for the industry.

Initiatives include a tool being developed by Intech in partnership with Oxford Brookes University, which calculates the embodied energy of building services.

The ventilation workshop included a debate on the potential benefits of lightweight ductwork such as pre-insulated ductwork or an innovative new cardboard duct developed by Gator, which has considerably lower embodied energy, as well as reduced transportation costs compared to conventional galvanised steel.

Meanwhile Philps Lig said it was developing a Lux service, developing that can be maintained or upgraded, rather than disposed of at the end of their operation.

For The Enterprise Centre – a new low carbon export building at the University of Anglia – BDP and Aechrom have been working with CIBSE to increase awareness of the opportunities and business benefits of resource efficiency.

The findings will be developed into a CIBSE Technical Memorandum on resource efficiency building services, and CIBSE is keen to hear about further examples via resourceefficiency@cibse.

Wrap turns to services

The building services industry is missing out on major opportunities to cut costs and it could improve project delivery through more efficient handling of resources.

The Waste Resources Action Programme (WRAP) is an independent, not-for-profit advisory body, which has formed a partnership with CIBSE to increase awareness of the opportunities and business benefits of resource efficiency.

The building services industry is missing out on major opportunities to cut costs and it could improve project delivery through more efficient handling of resources.

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CIBSE partnership aims to cut building services waste

Wilson's simplified design solution can use fewer components and materials that they were working to reduce the embodied value of both the fabric and services.

The findings will be developed into a CIBSE Technical Memorandum on resource efficiency building services, and CIBSE is keen to hear about further examples via resourceefficiency@cibse.

CIBSE Journal August 2013
Low Carbon Construction - Risks of Focus on Operational Energy

The IGT report recommends a whole life carbon appraisal. The risks of just considering operational energy include:

It would otherwise be possible to count an “energy saving” product as a good thing when it consumes more energy in its manufacture than it can save over its working lifetime.

that there is less pressure to reduce the high levels of materials waste in the industry.

that unnecessary increases in carbon emissions may be created by demolishing and replacing a building, where the carbon benefit of recycling existing structures is not taken into account.

The IGT report on Low Carbon Construction
Government Policy
‘improving our understanding of design approaches, including passive design, to balance energy demand and supply in the built environment is vital in enabling the industry to design and construct high performance, resource efficient buildings’.

The Government’s Industry Strategy: Construction 2025
Drivers for Resource Efficiency

The drivers for resource efficiency of building are to:

- reduce capital costs, price volatility and project risk, and help to provide a hedge against future risks of material shortages
- reduce the running costs by reducing the resources required to maintain and upgrade equipment
- demonstrate compliance with regulations and standards
- address the project brief or tender requirements.
**Defining Resource Efficiency**

Resource-efficient building services make the best use of materials, water and energy over the lifecycle of the plant and equipment. This includes:

- Reducing materials consumption and wastage;
- Increasing reuse and recycled content, and enabling reuse and recyclability at end of life;
- Using resources with no scarcity and source security issues;
- Using products with lower embodied carbon and embodied water;
- Reducing energy and water use during construction;
- Designing for deconstruction, and
- Enabling energy efficiency and water efficiency in use.

Adapted from WRAP definition of resource efficient construction
Aims of Project

- Resource efficiency in building services sector
- Engage with the industry to identify the barriers, challenges and opportunities.
- Set out how to deliver improvements in practice
- Improve awareness of opportunities & business benefits
- Produce a CIBSE guide on resource efficiency
- The opportunities in heating, cooling, ventilation, lighting and vertical transportation
Aims of The Workshops

CIBSE Journal – May 2013
Doing More With Less Article
Materials and Equipment

Bingham Canyon copper mine in Utah, USA

Around 26% of all extractable copper in the Earth’s crust has been lost as waste, rather than being recycled.
US Natural Gas and Oil Prices

Figure: U.S. Energy Information, adjusted for inflation, in various y
UK Final Energy Consumption by Fuel Type (1970-2013)
Electricity Consumption in the Home by Appliances 1990 to 2013

Chart 6  Electricity consumption by household domestic appliance, by broad type, UK (1970 to 2013)

Chart 7  Average energy consumption of new cold appliances, UK (1990 to 2013)

Chart 8  Average energy consumption of new wet appliances, UK (1990 to 2013)
### Construction Materials – From Cradle to Grave

#### STEEL
- **Quality of data:** The general quality of data is good. The use of steel is expected to remain stable in the long term.
- **Methods of analysis:** Steel is used in the construction industry, with the use of steel in the construction sector being the highest.
- **What are the values using these methods?** The steel industry uses figures of between 0.75kgCO₂/Ag for structural sections and 1.25kgCO₂/Ag for galvanised strip.
- **Benefits:** The benefits of steel use in construction are based on assumptions that the steel is sustainably sourced.

#### TIMBER
- **Inventory of Carbon and Energy (ICE) database in cradle-to-gate:** The ICE database contains a figure of 0.35kgCO₂/Ag for the carbon dioxide content of timber.
- **What are the values using these methods?** The ICE database contains a figure of 0.35kgCO₂/Ag for the carbon dioxide content of timber.
- **Benefits:** The benefits of timber use in construction are based on assumptions that the timber is sustainably sourced.

#### CONCRETE
- **Carbon Footprint Issues:** The general quality of data is good. The use of concrete is expected to remain stable in the long term.
- **Methods of analysis:** Concrete is used in the construction industry, with the use of concrete in the construction sector being the highest.
- **What are the values using these methods?** The ICE database contains a figure of 0.35kgCO₂/Ag for the carbon dioxide content of concrete.
- **Benefits:** The benefits of concrete use in construction are based on assumptions that the concrete is sustainably sourced.

#### END-OF-LIFE OUTCOMES
- **Recycling:** Staal scrap has a high value and has an efficient collection and capture infrastructure. Globally, it is estimated that 50% of steel scrap is captured. In the UK, 34% is captured from construction demolition and, for fancy framing products, 99% is captured or re-used.
- **Re-use:** A study carried out in 2003 estimated that 3% of structural sections are re-used. This is thought to be high and the actual figure is probably between 5-10%. Sections re-use mainly occurs in the agricultural sector.
- **Landfill:** The amount of steel that ends up in landfill from building demolition is a function of the area of demolition. The BRE Green Guide estimates that 6% of timber waste was used to make chipboard, suggesting 3% is recycled to its original or equivalent use.
- **Demolition:** Steel scrap is manufactured into products with the same value as the original material. Demolition does not take place.

### Notes
- About 6% is incinerated at end of life. Energy recovery is restricted by lack of infrastructure.
Environmental Impacts - Pressure to Extract...

...in sensitive environments
Aggregate quarry in Malaysian Jungle

...in unsafe conditions
Marble quarry in China
Fiscal Measures - Landfill Tax

There are two rates of Landfill Tax – a standard rate for active wastes, £72 per tonne and a lower rate of £2.50 per tonne for inactive or inert waste such as rocks and soil.

Landfill Tax

<table>
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<tr>
<th>Landfill Tax</th>
<th>Rate from 1 April 2012</th>
<th>Rate from 1 April 2013</th>
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<tbody>
<tr>
<td>Standard rate</td>
<td>£64/tonne</td>
<td>£72/tonne</td>
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<tr>
<td>Lower rate</td>
<td>£2.50/tonne</td>
<td>£2.50/tonne</td>
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</table>

HMRC checked on 22/7/14
Fiscal Measures - Aggregates Levy

The Aggregates Levy was introduced in 2002. This encourages recycling and the efficient and sustainable extraction and use of an important natural resource by charging £2.00 per tonne for sand, gravel and rocks subjected to commercial exploitation in the UK.

The Aggregates Levy is the most frequently given reason for the expanding recycled aggregates businesses since 2001.

| Aggregates Levy |
|-----------------|-----------------|
| **Rate from 1 April 2012** | **Rate from 1 April 2013** |
| Taxable aggregate | £2.00/tonne | £2.00/tonne |

HMRC checked on 22/7/14

How much you pay
You pay tax of £2 per tonne of sand, gravel or rock. You pay less on smaller amounts. For example, you’d pay £1 on half a tonne. You still pay tax if you import the materials.
WRAP – Resource Efficient Built Environment

Resource efficient built environment

WRAP’s approach to resource efficiency in the built environment drives financial savings while prioritising energy, waste, water and carbon reductions.

The construction and operation of the built environment consumes 60% of all materials, results in 33% of all waste and accounts for 45% of CO₂eq emissions in the UK.

Tackling the impacts associated with buildings and infrastructure - from design through in-use to demolition - is critical for meeting UK government’s 2050 greenhouse gas targets.
WRAP Resource Efficiency Diagram

Operational Impacts
- Energy
- Water
- Material Quantity

Embodied Impacts
- Reuse & Recycled Content
- Life-span & Durability
- End of Life & Recyclability

Wastage
Scarcity
## Rare Earth Elements

<table>
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<tr>
<th>Light Rare Earths (more abundant)</th>
<th>Major End Use</th>
<th>Heavy Rare Earth (less abundant)</th>
<th>Major End Use</th>
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<tr>
<td>Lanthanum</td>
<td>Phosphors, hybrid engines, metal alloys</td>
<td>Terbium</td>
<td>Phosphors, permanent magnets</td>
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<tr>
<td>Cerium</td>
<td>Phosphors, auto catalyst, petroleum refining, metal alloys</td>
<td>Dysprosium</td>
<td>Permanent magnets, hybrid engines</td>
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<tr>
<td>Praseodymium</td>
<td>Magnets</td>
<td>Erbium</td>
<td>Phosphors</td>
</tr>
<tr>
<td>Neodymium</td>
<td>Auto catalyst, petroleum refining, hard drives in laptops, headphones, hybrid engines</td>
<td>Yttrium</td>
<td>Red color, phosphors, ceramics, metal alloy agent</td>
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<tr>
<td>Samarium</td>
<td>Magnets</td>
<td>Holmium</td>
<td>Glass coloring, lasers</td>
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<td>Europium</td>
<td>Phosphors, red color for TV and computer screens</td>
<td>Thulium</td>
<td>Medical x-ray units</td>
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<td>Gadolinium</td>
<td>Magnets</td>
<td>Lutetium</td>
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<td>Scandium</td>
<td>Aerospace components</td>
<td>Ytterbium</td>
<td>Lasers, steel alloys</td>
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<td>Promethium</td>
<td>Nuclear batteries</td>
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Water Risk for Selected Materials from WRAP Analysis
China Controls 97% of the World Supply of Rare Earth Metals
Life Cycle Impacts – Embodied Carbon

Cumulative embodied and operational CO$_2$ emissions for a new air-conditioned office over 60 years

- Whole Life Embodied carbon
- Whole life - M & E Services only
- Total operational emissions
Ecological Footprint of Materials – More Than Just Carbon!

- Embodied energy
- Carbon footprint
- Water footprint
- Pollution
- Availability
- Recycled content

- Health and safety for builders
- Waste created
- Embodied energy of construction
- Pollution

Ease of deconstruction
Amount of waste created
Reusability
Recyclability
Waste management

Durability
Heat island effect impact
Porosity
Thermal properties
Role in biodiversity
Accessibility
Educational value
Aesthetic value
Pollution
Impact on human health
Environmental Product Declarations

Environmental Product Declaration

ABB drive for HVAC applications
ACH550 frequency converter, 4 kW power
Drivu® Low Voltage AC Drive

Select resource efficient equipment

ABB

Environmental product declaration

The Product
This environmental product declaration refers to Lindab’s Professor supply air beam. This product is manufactured at NovoClima Produktion AB in Göteborg, Sweden.

Manufacturing
Professor is based on a battery of fins. This battery consists of a series of aluminium fins on a copper pipe. The fins are in metallic contact with the copper pipe by way of the pipe being expanded. At the ends, copper connections are soldered in place, selected for the correct pressure drop and flow (15 or 22 mm).

The product is powder coated in the colour requested. Finally, the product is packaged and delivered to the customer by truck.

Materials included in a 1.8-metre Professor, 440 wide, suspended.

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<tbody>
<tr>
<td>% by wt</td>
<td>14.2 %</td>
<td>2.89 Kg</td>
<td>&lt; 10 g</td>
</tr>
<tr>
<td></td>
<td>2.93 Kg</td>
<td>&lt; 10 g</td>
<td>2.89 Kg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Material</th>
<th>Copper:</th>
<th>Battery:</th>
</tr>
</thead>
<tbody>
<tr>
<td>% by wt</td>
<td>14.4 %</td>
<td>2.93 Kg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Material</th>
<th>Stainless Steel:</th>
<th>System:</th>
</tr>
</thead>
<tbody>
<tr>
<td>% by wt</td>
<td>69.6 %</td>
<td>14.0 Kg</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Material</th>
<th>Paint coating:</th>
<th>Epoxy-polyester:</th>
</tr>
</thead>
<tbody>
<tr>
<td>% by wt</td>
<td>2.1 %</td>
<td>0.43 Kg</td>
</tr>
</tbody>
</table>

Packaging: Box, Pallet, Paper, Wood

Total: 26.4 Kg

Use
Professor is used for spaces which require cooling, where air is supplied through the beam. During operation, the product does not produce any demonstrable chemical emissions. Professor is maintenance free, apart from normal cleaning. The product has a technical life of at least 25 years.

Recycling
Lindab has a well-functioning recycling system. The company accepts its own products in return when they are no longer useful, because nearly all the materials can be recycled. Please contact Lindab for instructions with regard to return transport and packaging.
Why Engineers Must Make Resource Efficiency a Priority

SHOCK AND ORE

The impact of building services on the environment and why engineers must make resource efficiency a priority
The CIBSE Technical Memoranda is divided into three main parts.

1) Explains resource efficiency

2) Sets out the key principles

3) Covers the opportunities for resource efficiency in:-
   1. Heating
   2. Cooling
   3. Ventilation
   4. Lighting
   5. Lifts and escalators
The CIBSE TM56:2014

The aims of the CIBSE Technical Memoranda 56: 2014:

1) Help understand the principles and importance of resource efficiency

2) Provide guidance on principles and tools relating to resource efficiency

3) Set out opportunities to improve the resource efficiency of building services
Opportunities for Heating Sector

- Reducing demand for heating
- Systems design
  - Fuel
- Component selection
  - Layout
  - Materials
## Opportunities for Heating Sector

### Luna 4: Aluminium Heat Exchanger

<table>
<thead>
<tr>
<th>Material</th>
<th>With BRASS hydraulic group</th>
<th>With COMPOSITE hydraulic group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total weight (kg)</td>
<td>Total weight (kg)</td>
</tr>
<tr>
<td></td>
<td>48,2</td>
<td>46,9</td>
</tr>
<tr>
<td>Material %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Generic steel</td>
<td>45,5%</td>
<td>Generic steel</td>
</tr>
<tr>
<td>Cast Aluminium</td>
<td>25,7%</td>
<td>Cast Aluminium</td>
</tr>
<tr>
<td>Brass</td>
<td>8,8%</td>
<td>Brass</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>3,4%</td>
<td>Stainless Steel</td>
</tr>
<tr>
<td>Copper</td>
<td>3,3%</td>
<td>Copper</td>
</tr>
<tr>
<td>PP</td>
<td>2,1%</td>
<td>PP</td>
</tr>
<tr>
<td>Other materials</td>
<td>11,2%</td>
<td>Other materials</td>
</tr>
</tbody>
</table>

### Luna 4: Stainless Steel Heat Exchanger

<table>
<thead>
<tr>
<th>Material</th>
<th>With BRASS hydraulic group</th>
<th>With COMPOSITE hydraulic group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total weight (kg)</td>
<td>Total weight (kg)</td>
</tr>
<tr>
<td></td>
<td>44,0</td>
<td>42,8</td>
</tr>
<tr>
<td>Material %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upper shell</td>
<td>47,2%</td>
<td>Upper shell</td>
</tr>
<tr>
<td>Stainless Steel</td>
<td>18,4%</td>
<td>Stainless Steel</td>
</tr>
<tr>
<td>Brass</td>
<td>9,4%</td>
<td>Cast Aluminium</td>
</tr>
<tr>
<td>Copper</td>
<td>2,6%</td>
<td>Copper</td>
</tr>
<tr>
<td>Other materials</td>
<td>14,4%</td>
<td>Other materials</td>
</tr>
</tbody>
</table>
What Are The Opportunities For Heating Systems?
Designing out the need for plant and equipment?
Changing designs to be more resource efficient?
The standardisation of products and systems?
Label products with a list of materials and components?
Deconstruction manual?
Formalise the market for reusing or reconditioning equipment?
Opportunities for Cooling Sector

- System Type
  - Central or Local
  - Natural/Mechanical/Mixed

- Systems Design
  - Chiller Type
  - Thermal Storage
  - Fans/Pumps
  - Ductwork/Pipework
  - Controls, Dampers, Louvers, etc.

- Component Selection
  - Layout
  - Materials
Storage Systems

Phase change diagram showing the relationship between temperature and energy storage.

Thermal Storage System Schematic

Passive Cooling

www.climator.com

THERMAL ICE STORAGE
Chiller Control Systems
3D Printing of Components (MonoDraught)
Optimise Ductwork System Design – Doing More With Less
Opportunities for Ventilation Sector

- Natural Ventilation, Mechanical Ventilation and Mixed Mode
- Systems Design
  - Fans
  - Ductwork
  - Controls, Dampers, Louvers, etc.
- Component selection
  - Layout
  - Materials
Consider Alternative Materials For Distribution of Air
Issues Relating to Ventilation and Insulation
Opportunities for Resource Efficient Ventilation Systems

- **Design out the demand for services**
  - Considering natural ventilation system to reduce the amount of mechanical ventilation.

- **Challenge the brief and use best practice design calculations**
  - Carefully calculating the design air volumes and external pressure requirements to optimise design.
  - Taking an integrated design approach to ductwork design to reduce the amount of ductwork required and reducing the pressure drop.

- **Optimise system design**
  - Consider alternative materials for ductwork, such as fabric ductwork.

- **Consider alternative materials**
  - Specifying equipment with good environmental product declarations.

- **Select resource efficient equipment**
  - Assessing the opportunities to re-use existing ductwork and AHUs when refurbishing buildings.

- **Consider re-using existing systems (refurbishment)**
Resource Efficient Building Services

Opportunities for Lighting Sector

- Daylight and Electric Light
- Systems design
  - Lamps
  - Luminaires
  - Controls
- Component selection
  - Layout
  - Materials
How Do You Compare Products?

Since LED light bulbs are designed to use less energy than halogen spots, wattage is not a reliable way to gauge how bright the bulb is. Brightness is measured in Lumens.

With LED spotlights there is more to consider than just a direct Lumen comparison with the halogen equivalent. The superior light quality given off by LEDs and much lower bulb degradation rate over time must also be taken into account. This is why the stated Lumen output for an LED spotlight is often less than that quoted for a halogen spot bulb it replaces.
Environmental Impacts for Lighting

Figure 1-2. Life-Cycle Assessment Impacts of the Lamps Analyzed Relative to CFL
Phosphor Price Index 2011

Figure 1: Example of phosphor price index in 2011
(http://philips.to/1eQiiO6)
“It may be tempting for the lighting designer to just put 500 lux everywhere... However, this approach is highly wasteful and may well result in an unnecessary increase in energy consumption of more than 50%”

SLL Code for Lighting
What Do We Pay For?

Osram T5 Lumilux High Output

- T5 Fluorescent Tubes
- Available in 24W, 39W, 49W, 54W and 80W
- 24,000 hours lifetime
- Up to 50% more light than a T8 tube from the same length
- Available in very warm white, warm white, cool white, daylight

From £2.95

Buy now

Osram T8 Lumilux Fluorescent Tube

- T8 tubes
- Available in 10W, 15W, 16W, 18W, 30W, 36W, 38W, 58W and 70W
- Triphosphor tubes with higher efficiency and longer life
- Equivalent to: GE Polylux XL / Philips Master TL-D Super 80 / Sylvania Luxline Plus

From £2.78

Buy now

Sylvania T5 Standard

- T5 Fluorescent Tubes
- Available in 4W, 6W, 8W and 13W
- Only available in Warm White 3000K
- Ideal for small luminaires

From £1.81

Buy now

Philips T8 MASTER TL-D Super 80 Fluorescent Tube

- T8 tubes
- Available in 18W, 30W, 36W and 58W
- Triphosphor tubes with higher efficiency and longer life
- Equivalent to: GE Polylux XL / Osram T8 Lumilux / Sylvania Luxline Plus

From £2.64

Buy now
Opportunities for LED Lighting

Twice the light, half the size and all the sparkle. Brilliant.

When you need a brilliant light source that delivers maximum punch, adds richness with deeply saturated colors and crisp, defining shadows that make your subject sparkle. You need Philips Lumileds LUXEON® S high lumen density array. LUXEON S LEDs deliver the highest quality of light and industry-leading punch for high center beam intensity and uniformity and are ideal for retail, architectural and entertainment applications that require precise light beam control.
Ten LED (60 Watt GLS Equivalent) Lamps
Japanese scientists develop OLED material free of rare metals

By HIROHIKO NAKAMURA/ Staff Writer

Japanese researchers said they have developed a new material for organic light-emitting diodes (OLEDs) that is free of rare metals and can slash the costs to produce smartphone displays and other appliances.

The team led by Chihaya Adachi, director of Kyushu University's Center for Organic Photonics and Electronics Research, said they created a dicyanobenzene derivative, an organic chemical compound that emits light at high efficiencies, without the use of rare metals.

The material is as cheap as fluorescent substances and is as efficient in electroluminescence, or the use of electrons to induce light emission, as phosphorous substances, they said.

The team named the new material’s light-emitting features "hyperfluorescence."

"We wish to tie up with Japanese manufacturers and strive to commercialize our Japan-born technology at an early date," Adachi said.

Existing OLEDs use fluorescent and phosphorescent materials. Fluorescent substances are cheap but they have low efficiencies of...
Pay Per LUX

“I told Philips, ‘Listen, I need so many hours of light in my premises every year. You figure out how to do it. If you think you need a lamp, or electricity, or whatever – that’s fine. But I want nothing to do with it. I’m not interested in the product, just the performance. I want to buy light, and nothing else.’

Thomas Rau
Opportunities for Vertical Transportation

- System Type
  - Lifts and Escalators
  - Design and Performance

- Systems Design
  - Lifts, Stairs and Escalators
  - Motors
  - Configurations
  - Controls

- Component Selection
  - Layout
  - Materials
KONE Monospace Materials Content

Environmental product declaration

Product material content
KONE MonoSpace® is mainly composed of steel and cast iron.

<table>
<thead>
<tr>
<th>Material weight %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminum</td>
</tr>
<tr>
<td>Cast iron</td>
</tr>
<tr>
<td>Copper</td>
</tr>
<tr>
<td>Stainless steel</td>
</tr>
<tr>
<td>Steel</td>
</tr>
<tr>
<td>Steel (zinc coated)</td>
</tr>
<tr>
<td>Plastics</td>
</tr>
<tr>
<td>Rubber</td>
</tr>
<tr>
<td>Glass</td>
</tr>
<tr>
<td>Others</td>
</tr>
<tr>
<td>Electronics and electromechanical components</td>
</tr>
</tbody>
</table>
Materials

Environmental product declaration

Product material content
The KONE TransitMaster™ 140 escalator is mainly composed of coated and uncoated steel, and aluminum.

<table>
<thead>
<tr>
<th>Material</th>
<th>Weight (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel (zinc coated)</td>
<td>39.0</td>
</tr>
<tr>
<td>Steel (uncoated)</td>
<td>33.0</td>
</tr>
<tr>
<td>Aluminium</td>
<td>12.6</td>
</tr>
<tr>
<td>Cast iron</td>
<td>6.7</td>
</tr>
<tr>
<td>Stainless steel</td>
<td>6.2</td>
</tr>
<tr>
<td>Others</td>
<td>0.9</td>
</tr>
<tr>
<td>Plastics</td>
<td>0.7</td>
</tr>
<tr>
<td>Rubber</td>
<td>0.7</td>
</tr>
</tbody>
</table>
Control Systems and Panels

MEC32 Traction VVVF Panel

MEC32 Hydraulic Panels

VVVF CONTROL PANELS
- Open Loop or Closed Loop
- Up to 32 floors
- Up to 2.00 m/s
- Up to 90 KW
- Serial or parallel signalisation
- Powerful fault finding software
- Built-in modem for remote support
- Selective doors
- Short floors
- Bridging detection
- Fire fighters control
- Fault log
- Lift testing commands
Metallic Materials Often Dominate Building Services

Materials Used in Building Services
Embodied Energy Data for Aluminium

<table>
<thead>
<tr>
<th>Main Material</th>
<th>No. Records</th>
<th>Average EE</th>
<th>Standard Deviation</th>
<th>Minimum EE</th>
<th>Maximum EE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aluminium</td>
<td>111</td>
<td>157.1</td>
<td>104.7</td>
<td>8.0</td>
<td>382.7</td>
</tr>
<tr>
<td>General</td>
<td>111</td>
<td>157.1</td>
<td>104.7</td>
<td>8.0</td>
<td>382.7</td>
</tr>
<tr>
<td>50% Recycled</td>
<td>4</td>
<td>108.6</td>
<td>53.4</td>
<td>58.0</td>
<td>184.0</td>
</tr>
<tr>
<td>Other Specification</td>
<td>3</td>
<td>146.5</td>
<td>79.3</td>
<td>55.0</td>
<td>193.5</td>
</tr>
<tr>
<td>Predominantly Recycled</td>
<td>28</td>
<td>17.9</td>
<td>8.7</td>
<td>8.0</td>
<td>42.9</td>
</tr>
<tr>
<td>Unspecified</td>
<td>14</td>
<td>169.1</td>
<td>67.0</td>
<td>68.0</td>
<td>249.9</td>
</tr>
<tr>
<td>Virgin</td>
<td>62</td>
<td>224.1</td>
<td>68.5</td>
<td>39.2</td>
<td>382.7</td>
</tr>
</tbody>
</table>

Material Scatter Graph

© University of Bath
# Embodied Energy Data for Glass

## Glass

### Embodied Energy (EE) Database Statistics - MJ/Kg

<table>
<thead>
<tr>
<th>Main Material</th>
<th>No. Records</th>
<th>Average EE</th>
<th>Standard Deviation</th>
<th>Minimum EE</th>
<th>Maximum EE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Glass</td>
<td>97</td>
<td>20.08</td>
<td>9.13</td>
<td>2.56</td>
<td>62.10</td>
</tr>
<tr>
<td>Glass, Fibreglass</td>
<td>22</td>
<td>25.58</td>
<td>8.53</td>
<td>11.00</td>
<td>41.81</td>
</tr>
<tr>
<td>Market Average</td>
<td>1</td>
<td>30.00</td>
<td>30.00</td>
<td>30.00</td>
<td>30.00</td>
</tr>
<tr>
<td>Predominantly Recycled</td>
<td>2</td>
<td>11.90</td>
<td>11.90</td>
<td>11.90</td>
<td>11.90</td>
</tr>
<tr>
<td>Unspecified</td>
<td>16</td>
<td>26.24</td>
<td>8.41</td>
<td>11.00</td>
<td>41.81</td>
</tr>
<tr>
<td>Virgin</td>
<td>3</td>
<td>24.85</td>
<td>10.25</td>
<td>17.60</td>
<td>32.10</td>
</tr>
<tr>
<td>Glass, General</td>
<td>75</td>
<td>18.50</td>
<td>8.73</td>
<td>2.56</td>
<td>62.10</td>
</tr>
<tr>
<td>50% Recycled</td>
<td>1</td>
<td>7.00</td>
<td>7.00</td>
<td>7.00</td>
<td>7.00</td>
</tr>
<tr>
<td>Market Average</td>
<td>4</td>
<td>16.81</td>
<td>5.87</td>
<td>12.30</td>
<td>25.09</td>
</tr>
</tbody>
</table>

### Material Scatter Graph

![Material Scatter Graph](image)

Embodied energy (MJ/Kg) vs. Year of data.
Tools For Assessing Embodied Carbon
Virgin or Recycled Polyester

Figure 2: Manufacturer's comparison between virgin natural polyester and polyester using recycled post consumer waste (Based on published data specific to the Repreve brand for textured polyester yarn)
WRAP Resources for Construction Industry

What is resource efficiency?
Learn about how you can take action using our tools and guidance.

Built Environment Commitment
New Commitment provides an easy and practical framework for action.

Embodied Carbon Database
Share and compare embodied carbon data for buildings at each project stage.

Clients
Guidance to help clients implement resource efficient actions.

Designers
Tools and guidance for design teams.

Contractors
Tools to help principal contractors reduce waste, carbon and water.

Refurbishment
‘Greening’ existing residential, commercial and industrial buildings.

Specialist and Sub Contractors
Practical information on saving money and reducing waste.

Products, Materials and Waste
Opportunities to be more resource efficient with construction materials.

measuRE
A flexible tool covering resource use during construction and operation.

eNewsletter
Register to receive our latest news. View a previous update.

Opportunities to take action
Our guide to optimising resource efficiency in refurbishment and fit-out.