Introduction on Sustainability

Material Dependence

Strumenti dell'Ingegneria per l'Industria 4.0

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Question

What does sustainable manufacturing mean?

Manufacturing

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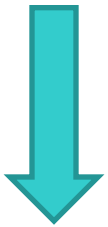


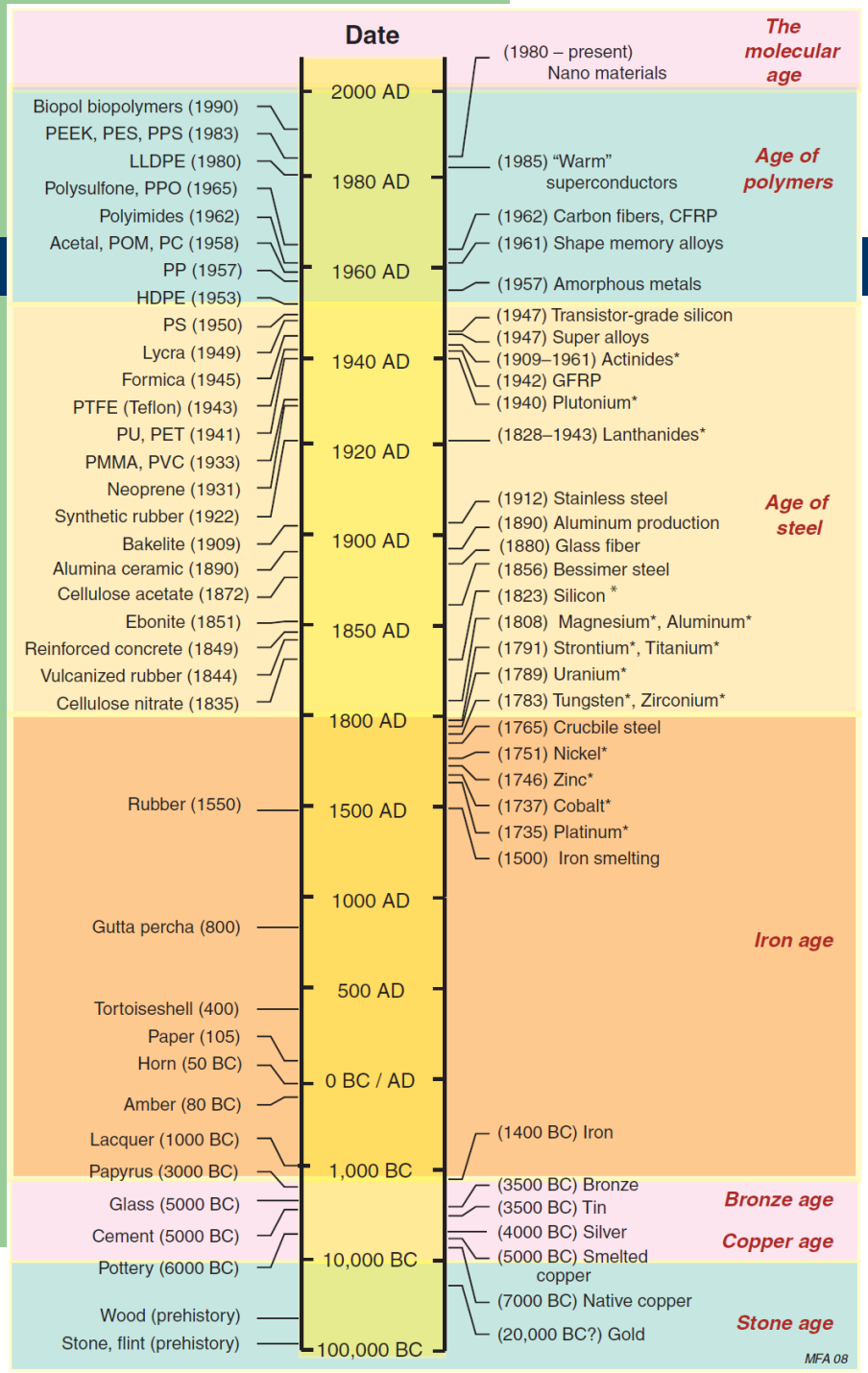
- The word *manufacture* is derived from two Latin words *manus* (hand) and *factus* (make); the combination means “made by hand”.
- “Made by hand” accurately described the fabrication methods that were used when the English word “*manufacture*” was first coined around 1567 A.D.
- Most modern manufacturing operations are accomplished by mechanized and automated equipment that is supervised by human workers.

Sustainable development

- There are several definitions of “sustainability”.

- Sustainable Development: the “*development that meets the needs of the present without compromising the ability of future generations to meet their own needs*”. World Commission on Environment and Development (1987)
- Sustainable manufacturing involves “*the creation of manufactured products that use processes that minimize negative environmental impacts, conserve energy and natural resources, are safe for employees, communities, and consumers and are economically sound*”. U.S. Department of Commerce.
- Sustainable Manufacturing as a “*system approach for the creation and distribution (supply chain) of innovative products and services that: minimizes resources (inputs such as materials, energy, water, and land); eliminates toxic substances; and produces zero waste that in effect reduces green house gases, e.g., carbon intensity, across the entire life cycle of products and services*". Rachuri et al.
- Sustainable Manufacturing as *the essence of business, whose main purpose should be the creation of wealth throughout its whole system*.

Timeline

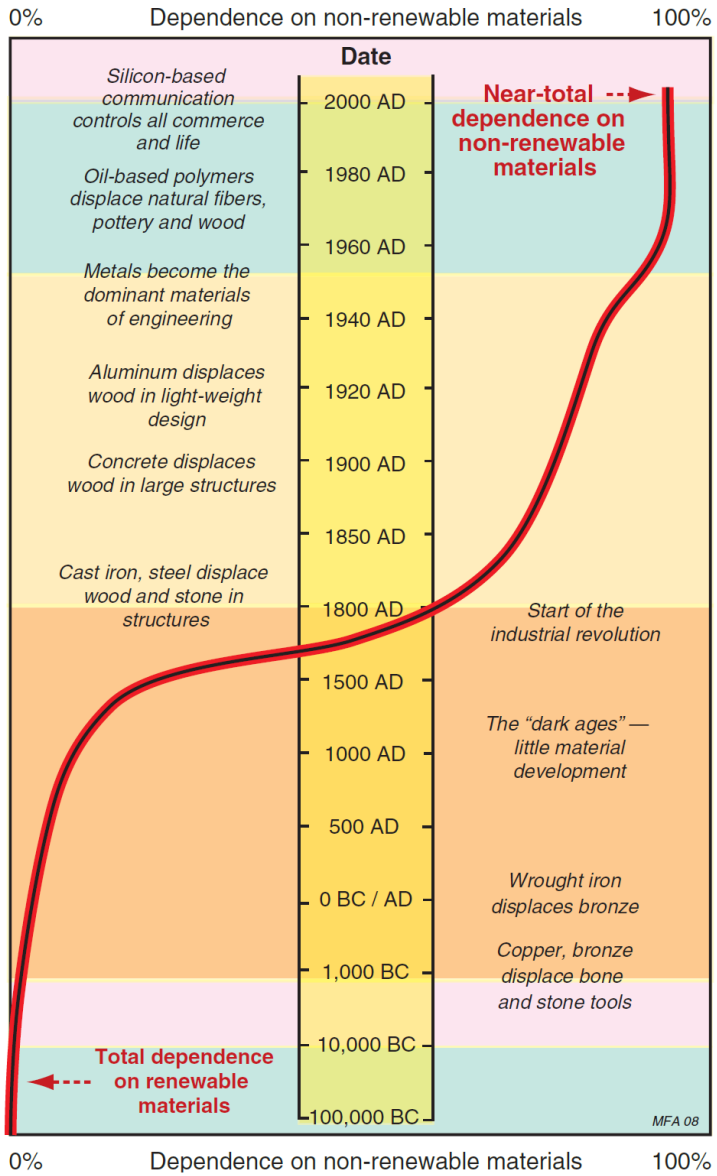


The materials always had an enormous impact on the advance of the mankind.

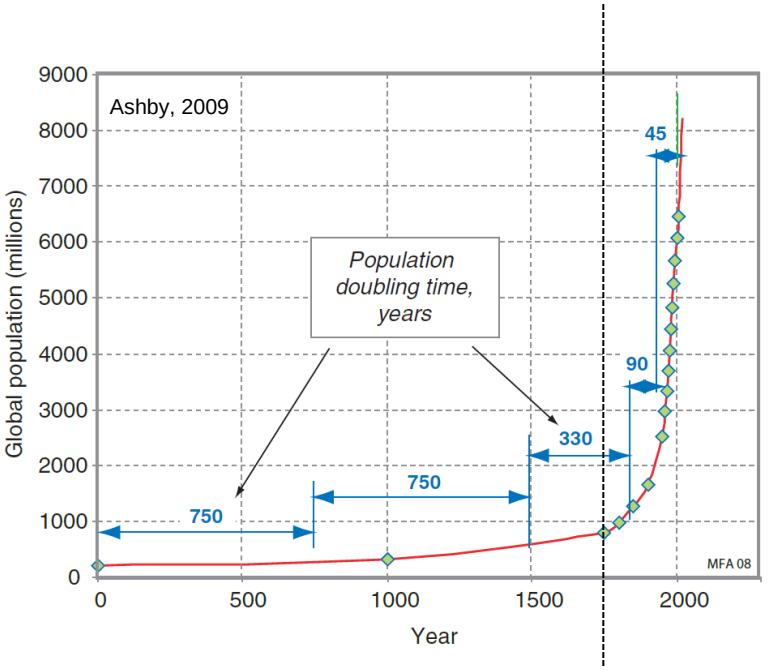
In fact, the ages of mankind took their names from the different materials used:

- Stone age
- Age of copper
- Bronze age
- Iron age
- Age of steel
- Age of polymers

Material Dependence



The increasing dependence on non-renewable materials over time, unimportant when they are plentiful but an emerging problem as they become scarce.



Global population growth over the last 2000 years, with the doubling time marked

Learned dependency

Over time our dependence on materials has progressively changed from a reliance on renewable materials to one that relies on materials *that consume resources that cannot be replaced*.

As little as 300 years ago, the few non-renewables (iron, copper, tin, zinc) were used in such *small quantities* that the resources from which they were drawn were nearly inexhaustible.

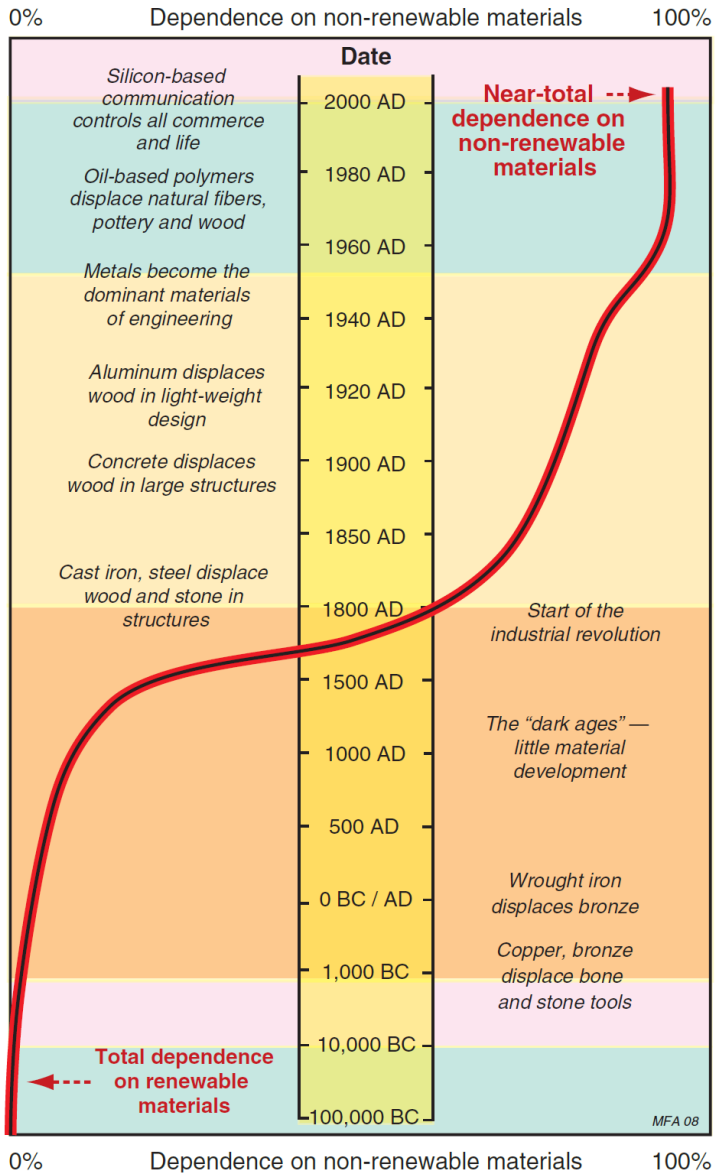
By the end of 20th century non-renewables *displaced almost totally renewables*, increasing our **dependence** on them.

Materials and the environment

All human activity has some impact on the environment in which we live.

The environment has some capacity to cope with this impact, so that a certain level of impact can be *absorbed without lasting damage*, but it is clear that current human activities exceed this threshold.

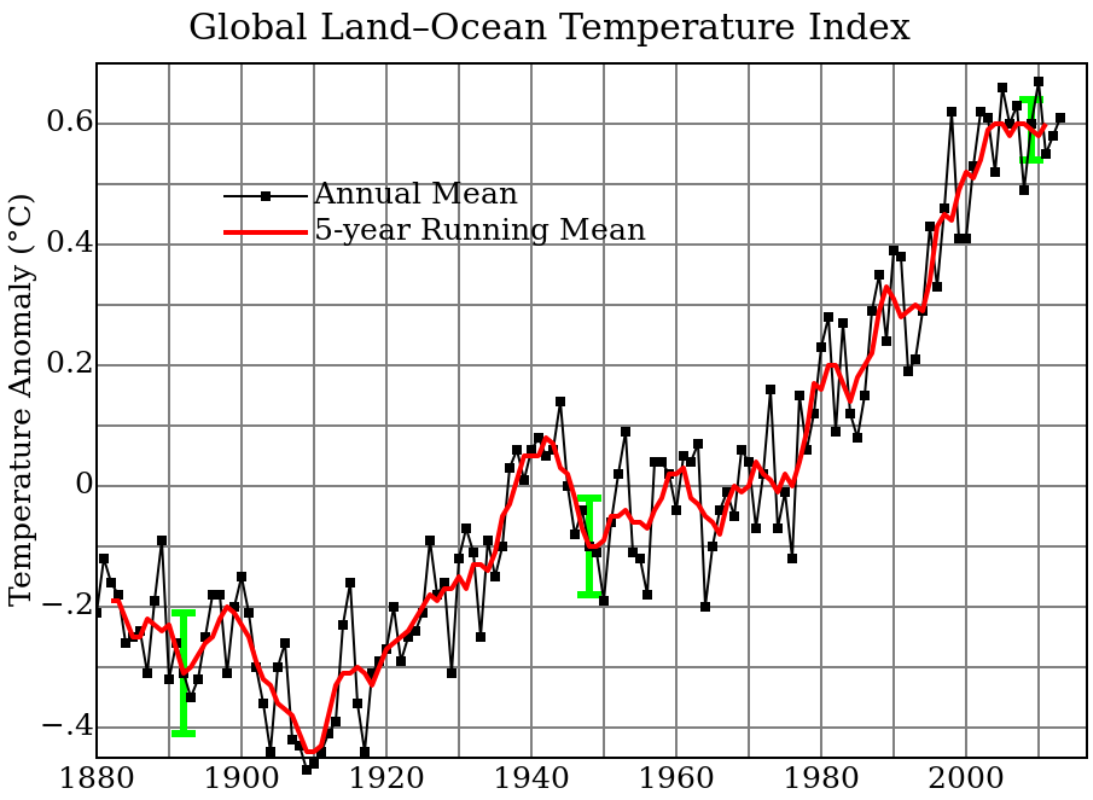
Material Dependence



the "Black Country"

- Some localized problems that have been corrected today.
- The change now is that some aspects of industrialization have begun to influence the environment on a global scale.

Global effects



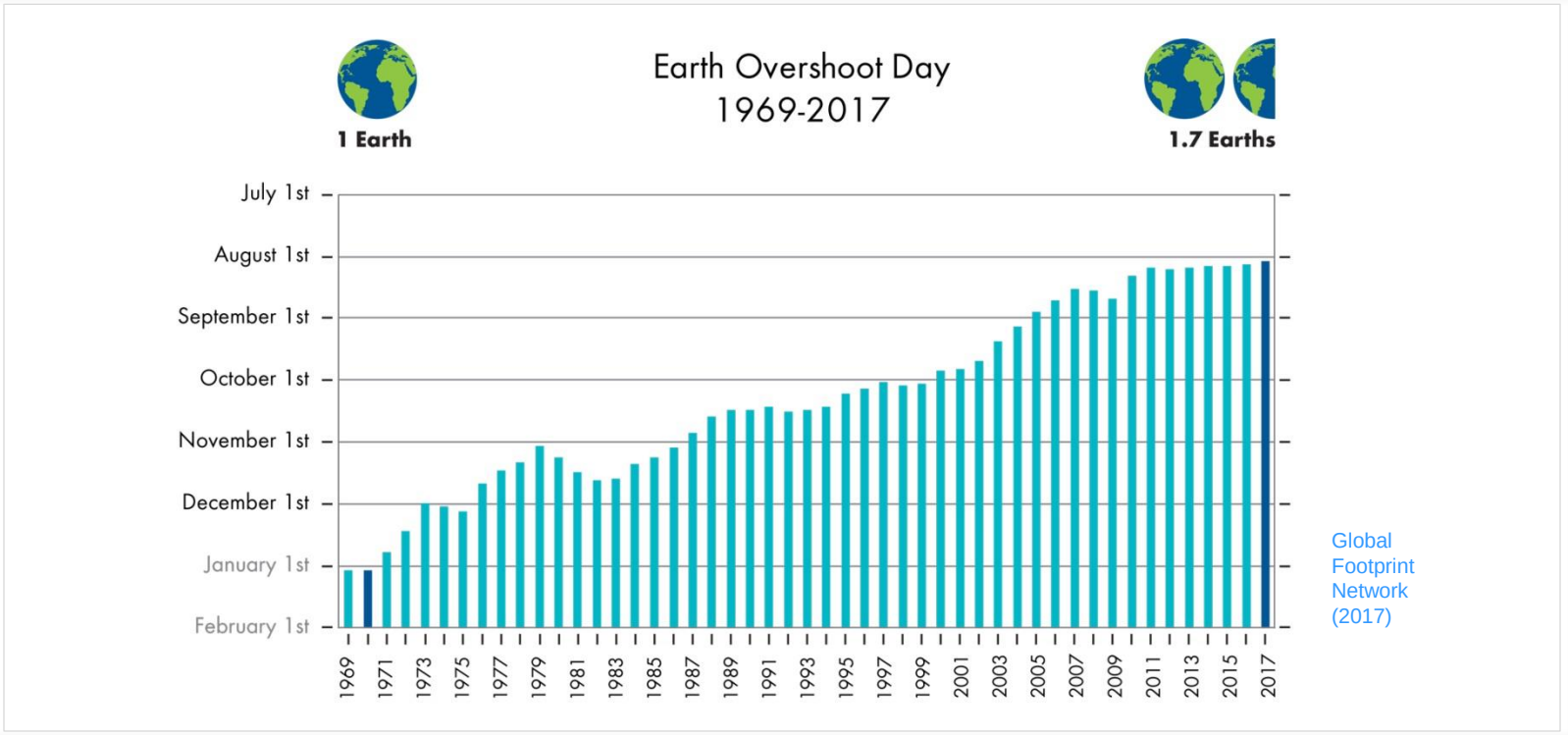
Source: NASA Goddard Institute for Space Studies

Materials and the environment

- 1798: “the power of population is so superior to the power of the Earth to produce subsistence for man that premature death must in some shape or other visit the human race” (*Thomas Malthus*).
- 1972: “if current trends continue unchanged […] humanity is destined to reach the natural limits of development within the next 100 years.” (a group of scientists known as the *Club of Rome)*
- 1987: “many aspects of developed societies are approaching… saturation, in the sense that things cannot go on growing much longer without reaching fundamental limits. This does not mean that growth will stop in the next decade, but that a declining rate of growth is foreseeable in the lifetime of many people now alive. In a society accustomed […] to 300 years of growth, this is something quite new, and it will require considerable adjustment (WCED,1987). ”

Overshooting

- Environmental stress increase



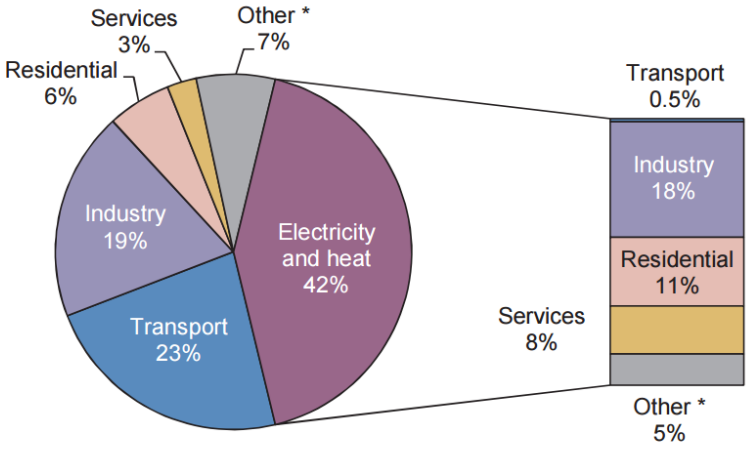
Global Footprint Network (2017)

- ✓ The carbon footprint makes up 60% of humanity's Ecological Footprint.
- ✓ Reducing the carbon component of humanity's Ecological Footprint by 50% would move the date of Overshoot Day by 89 days, or about three months.

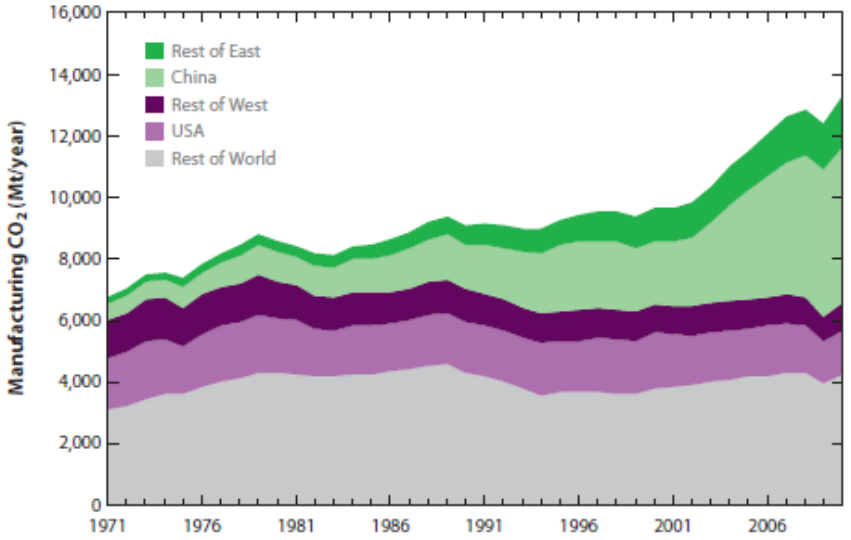
Impact of manufacturing

- Environmental responsibility of the manufacturing sector

Breakdown analysis of the World CO_2 emission by sectors in 2013



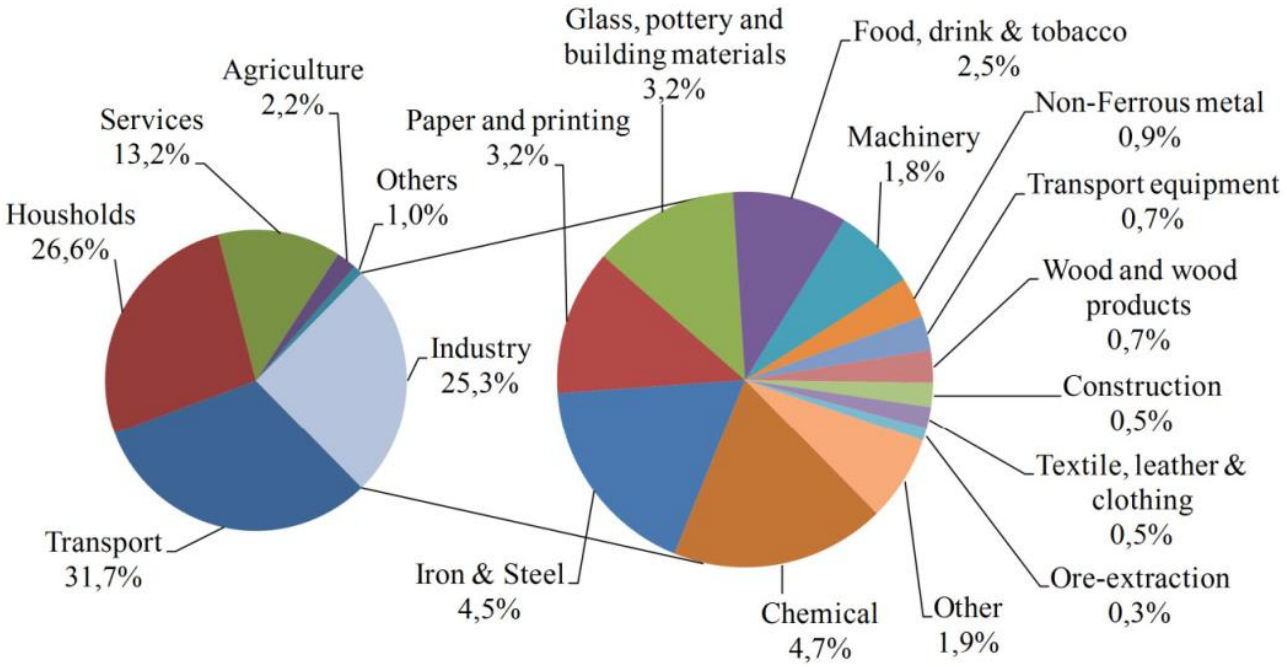
International European Agency, IEA (2014)



Gutowski et al. (2013)

Energy share

EU27 total energy consumption share in 2010



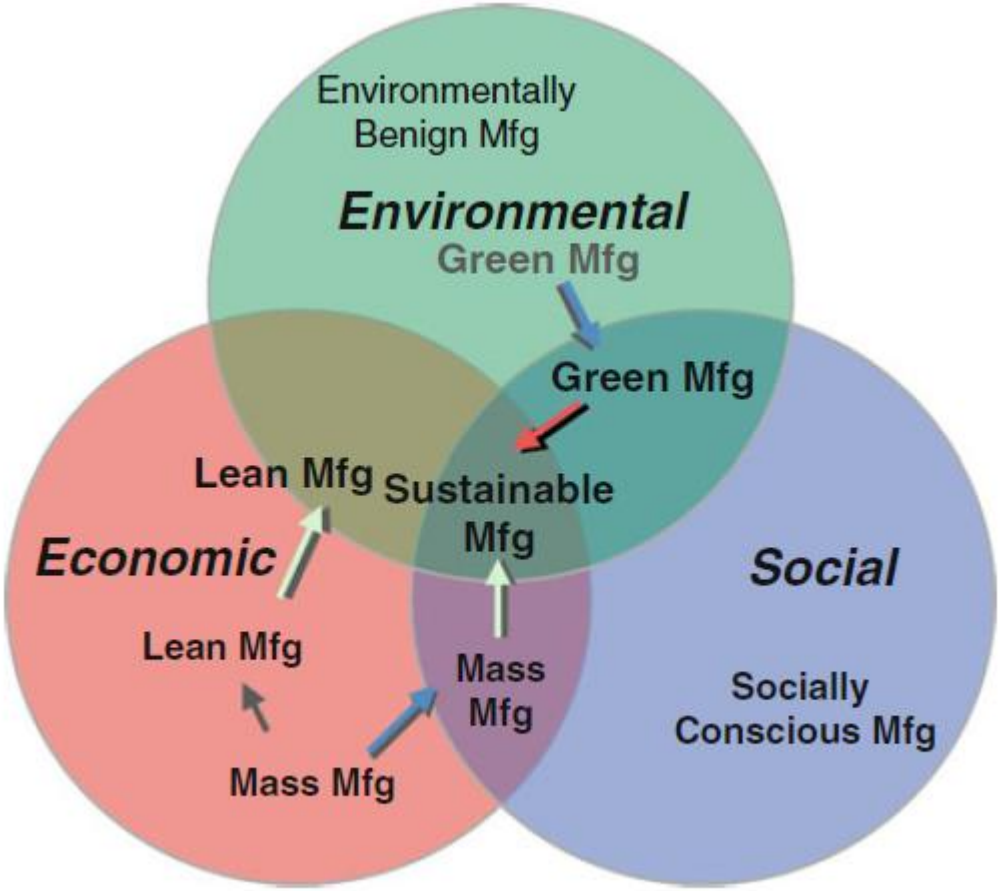
Source: Key World Energy Statistics 2011
Eurostat Energy Statistics 2010

Materials and the environment

It makes sense to explore the ways in which materials are used in design and how this might change as environmental prerogatives become increasingly pressing.

Materials have to be manufactured into products.

Triple bottom line



Sustainable development goals

http://www.un.org/

References and further readings

- Michael F. Ashby
  Materials and the Environment: Eco-Informed Material Choice
  Elsevier

- David Dornfeld, Editor
  Green Manufacturing Fundamentals and Applications
  Springer

- **Handbook on Life Cycle Assessment**
  Operational Guide to the ISO Standards
  Kluwer Academic Publishers