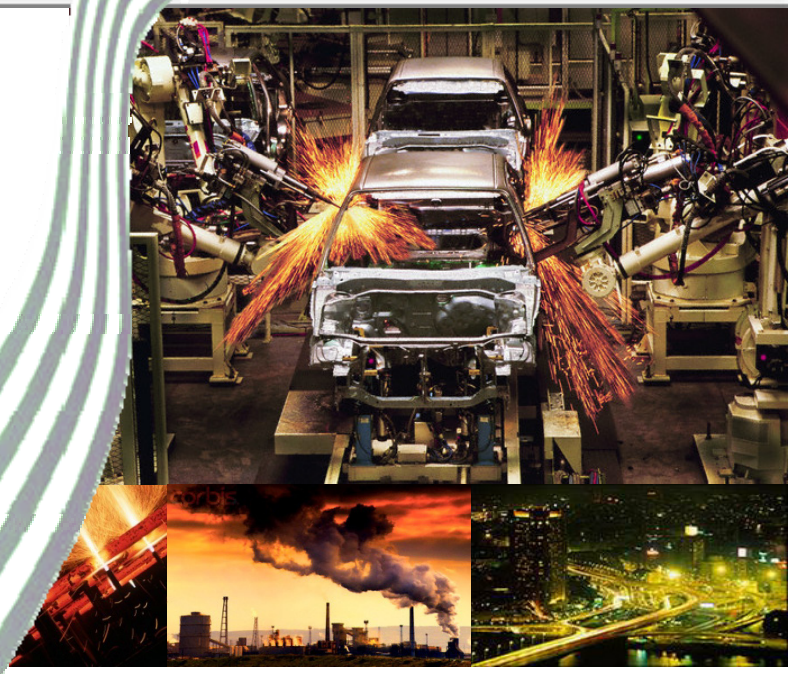
Modelling the Embodied Product Energy



Presented by: Professor Shahin Rahimifard

Director of Centre for Sustainable Manufacturing and Reuse/Recycling Technologies (SMART)

Loughborough University

Centre for Sustainable MAnufacturing and Reuse/Recycling Technologies

WWW.lboro.ac.uk/smart

Loughborough University

- 120 Miles (170 km) North of London
- 15,000 students, 3,000 staff, 3 faculties, 23 departments, 433 acre site
- University of the year 2008 in Sunday Times University Guide
- 6 Queen's Anniversary Prizes for Research and Teaching - matched only by Oxford
- Companies sited on campus include:
  - Henry Ford College for retail and management training of Ford employees
  - Rolls-Royce Fuel Cells facility
  - Systems Engineering Innovation Centre (SEIC) - BAE SYSTEMS

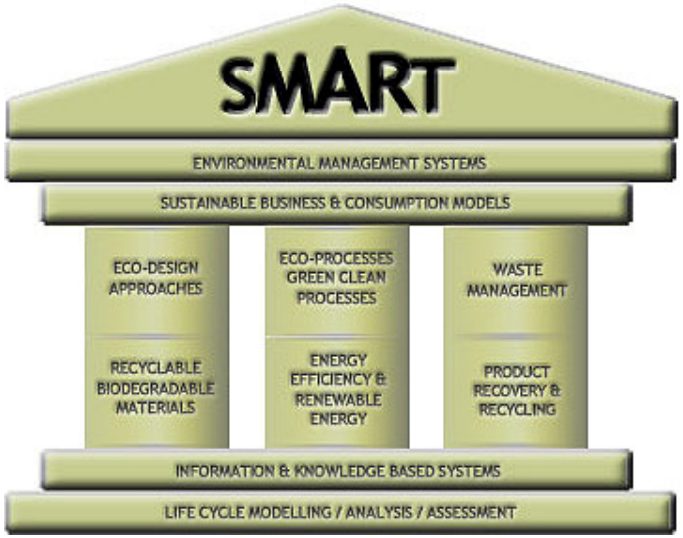
Centre for Sustainable Manufacturing and Recycling/Reuse Technologies (SMART)

- SMART is a R&D Centre established in 2004 at Loughborough University.

- Its remit is to develop strategies, methodologies and supportive technologies for a sustainable approach to design, production, consumption and disposal of products that meets the customers needs as well as legislative, environmental and ethical standards.

- Current Projects on :-

  - Sustainable product design and manufacture
  - Modelling the product embodied energy for low carbon manufacturing
  - Automation in remanufacturing, reuse and recycling technologies
  - Computer Aided RECYCLING Process Planning (CA***R***PP)
  - Sustainable business models to support product service systems
  - Product personalisation to support sustainable consumption



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Energy Trends

Energy is fundamental to the quality of our lives. Nowadays, we are totally dependent on an abundant and uninterrupted supply of energy for living and working. It is a key ingredient in all sectors of modern economies.

(European Commission)

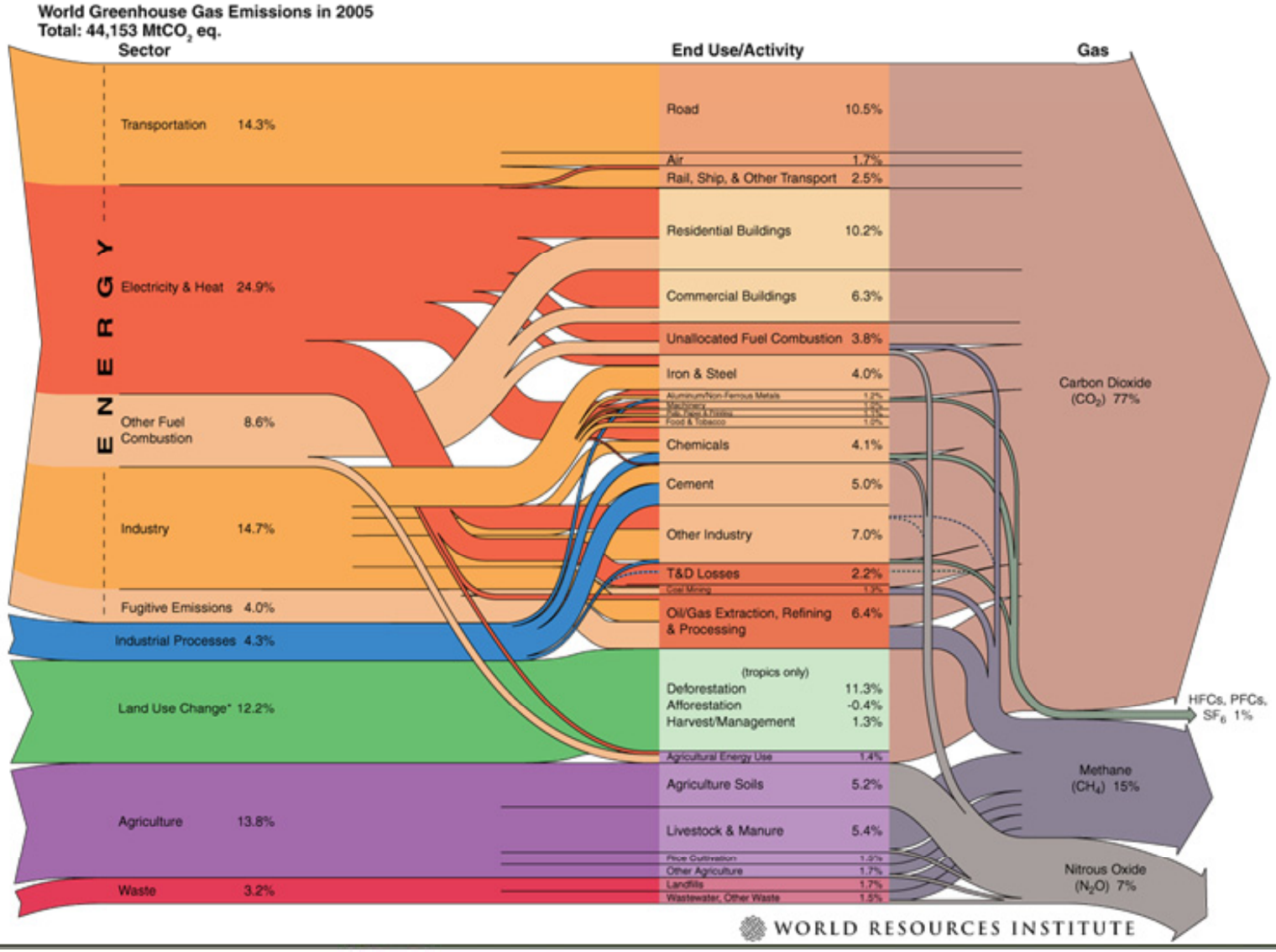
Energy Trends - Impact on Climate Change

The results show a "best estimate" of 4°C being reached by 2070, with a possibility that it will come as early as 2060.

"If greenhouse gas emissions are not cut soon then we could see major climate changes within our own lifetimes.*"

** Richard Betts, 2009, Met Office Hadley Centre, Research commissioned by the Department of Energy and Climate Change (DECC), http://www.metoffice.gov.uk/*

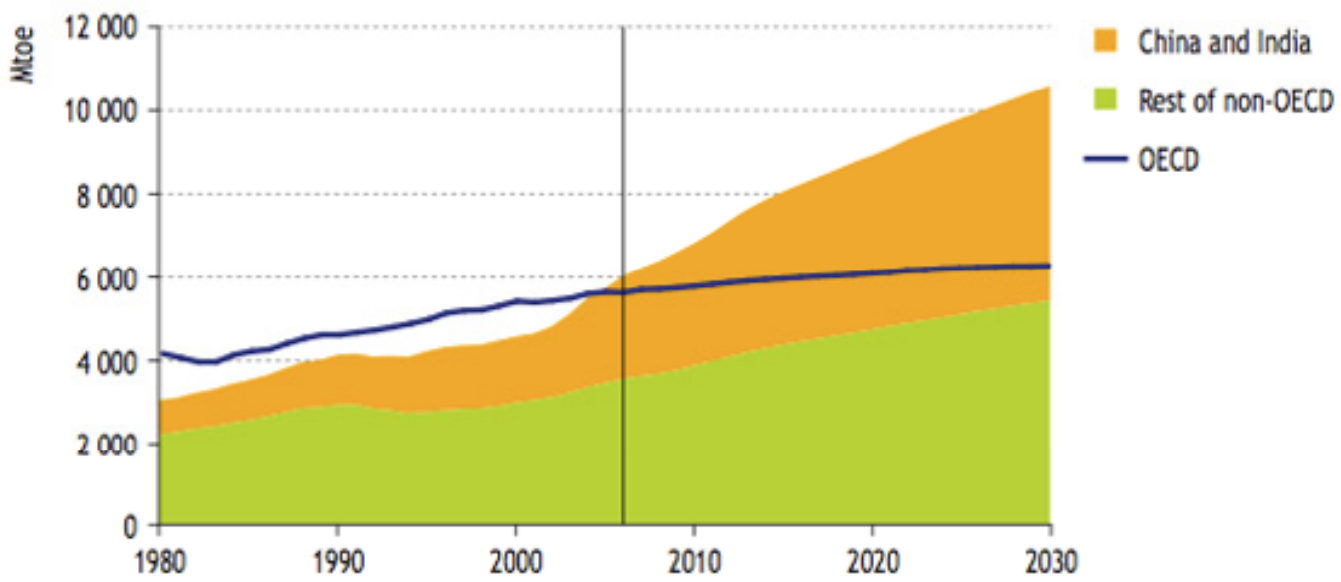
Energy Trends – World Greenhouse Gas Emissions: 2005



Energy Trends – Worldwide Demand

World Energy demand is expected to continue to increase over the coming decades, with demand estimated to be more than 45% higher in 2030 when compared to today's levels.

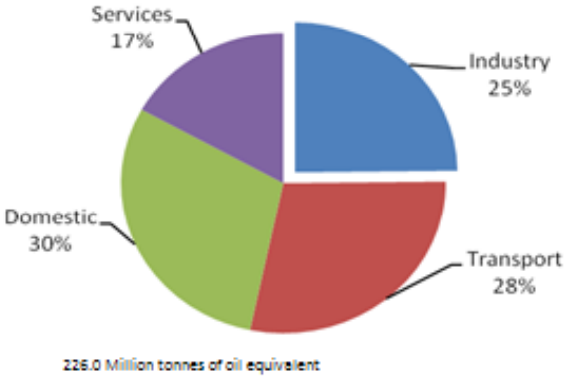
(International Energy Agency, 2008, World Energy Outlook)



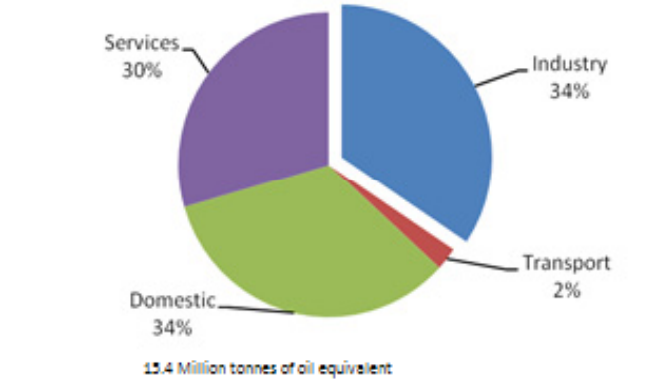
World primary energy demand by region

Energy Trends - UK

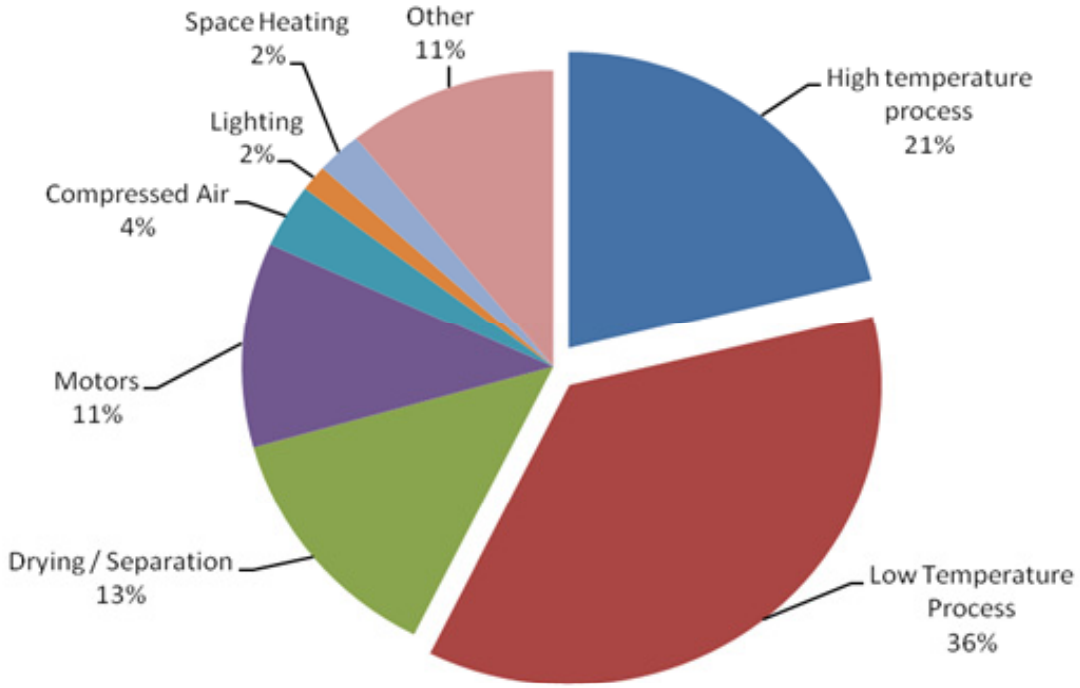
Final Energy Consumption in primary energy equivalents, 2007



Final Energy Consumption (electricity) in primary energy equivalents, 2007



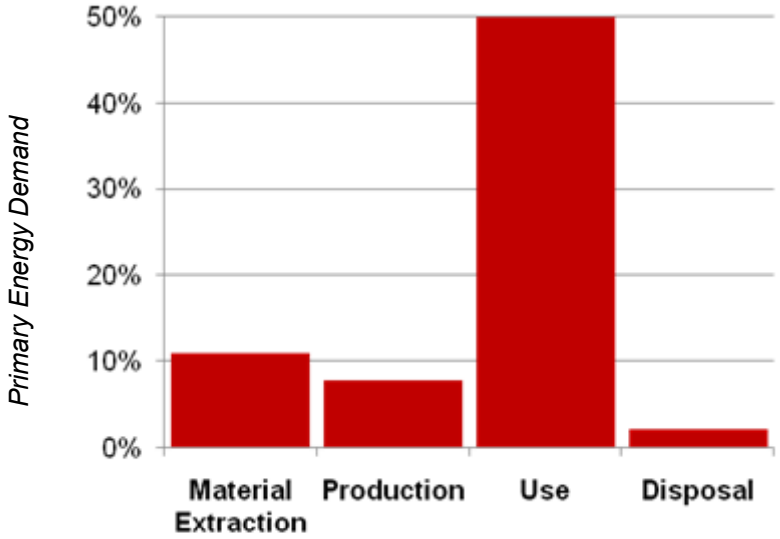
Industrial energy consumption by type of use, 2009



BERR 2009 Energy Report, *www.berr.gov.uk/energy/*

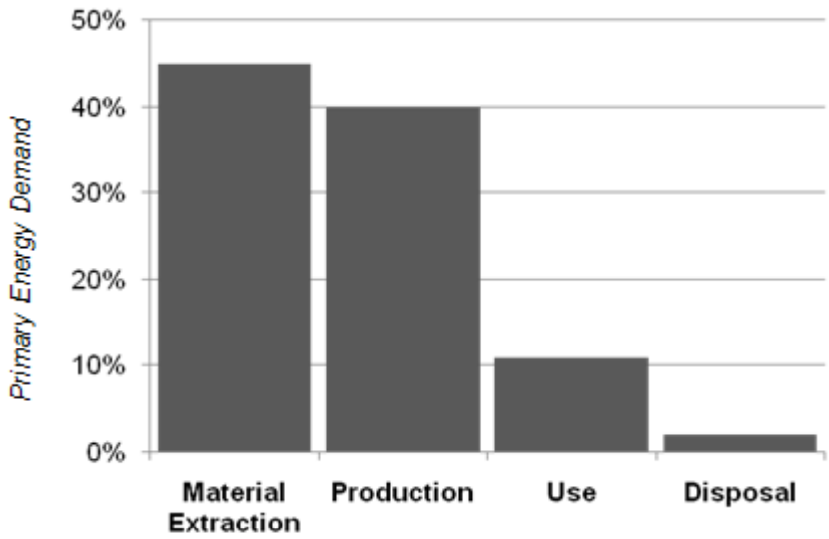
Energy Trends : Differences in Primary Energy Demand in a Product Life Cycle

Automotive Sector



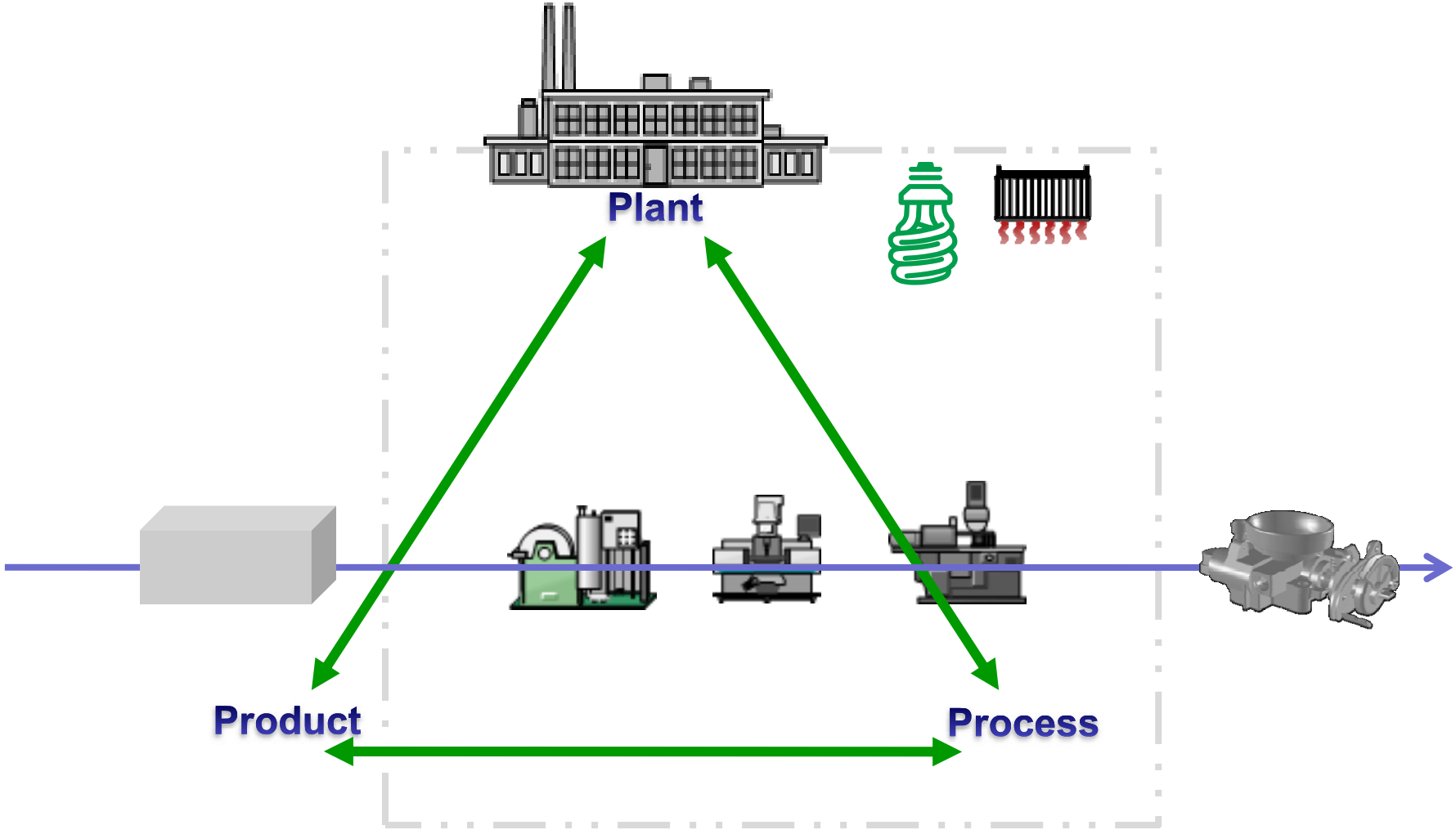
Schweimer et al., 2000

Electronic Devices

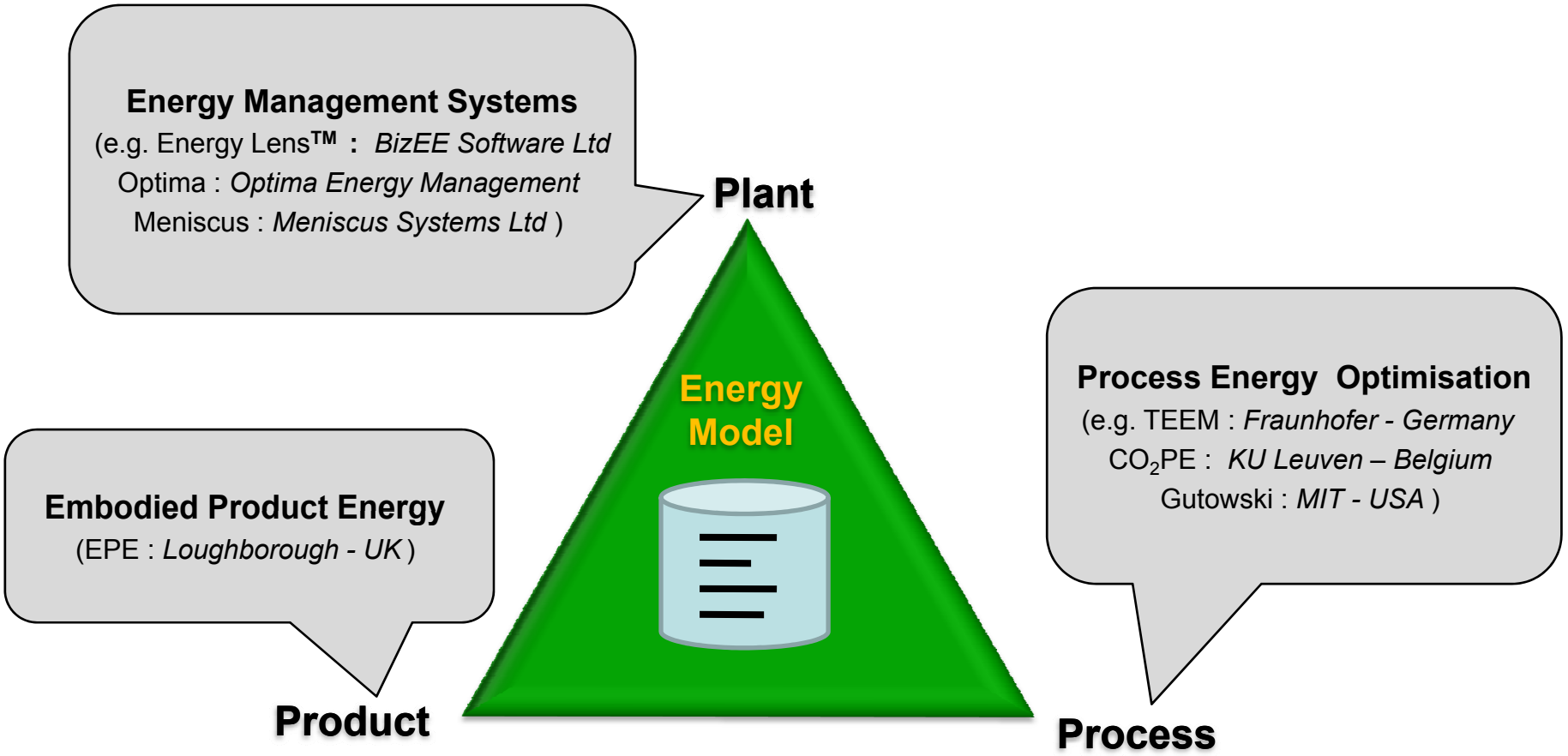


Basdere, 2004

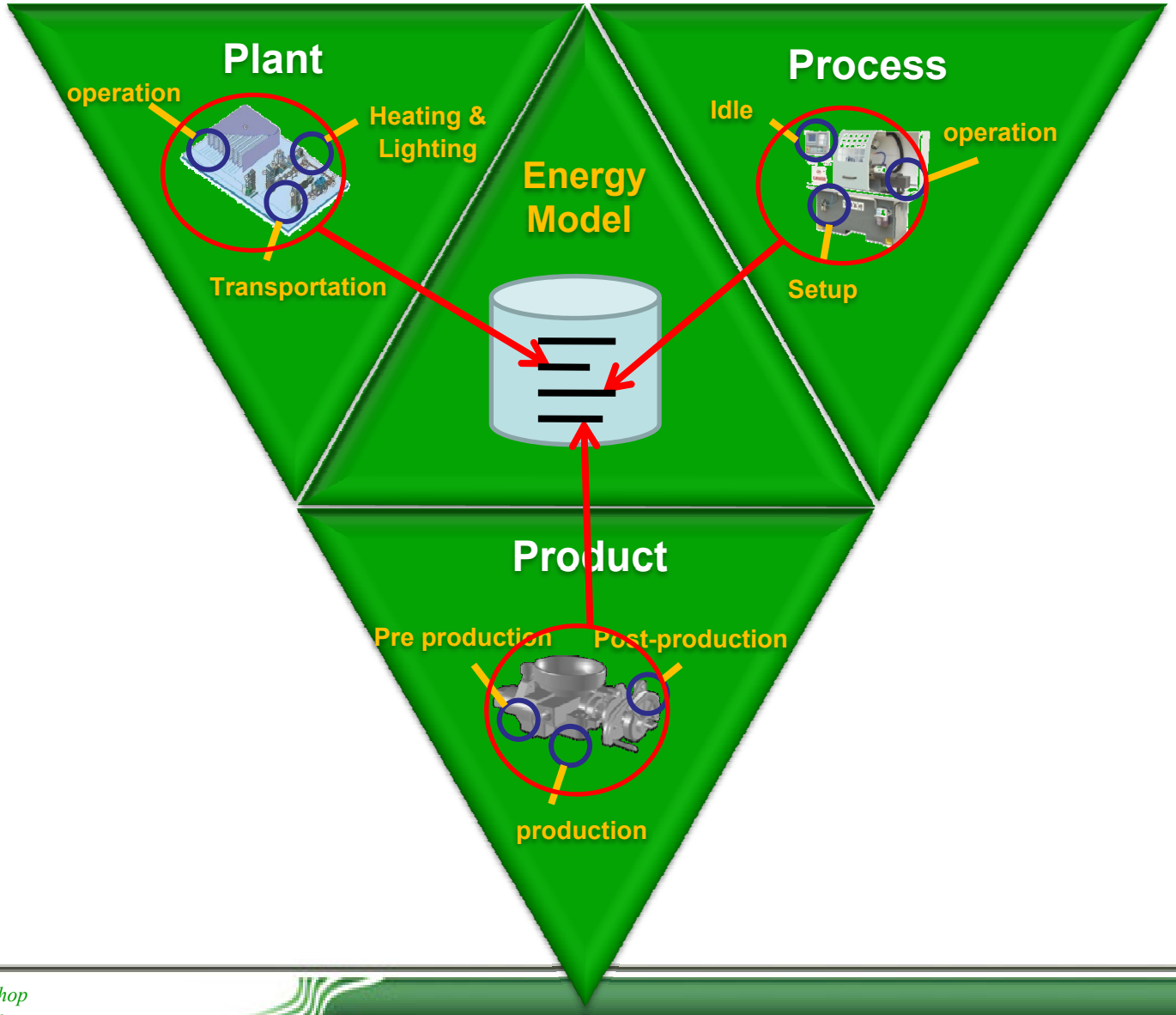
A High-level View of Energy Flows within Manufacturing



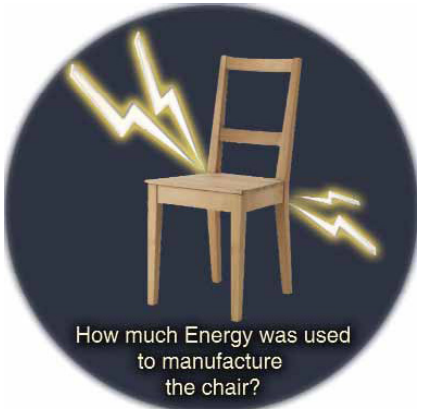
Plant, Process, & Product (3P) Approach for Energy Minimisation

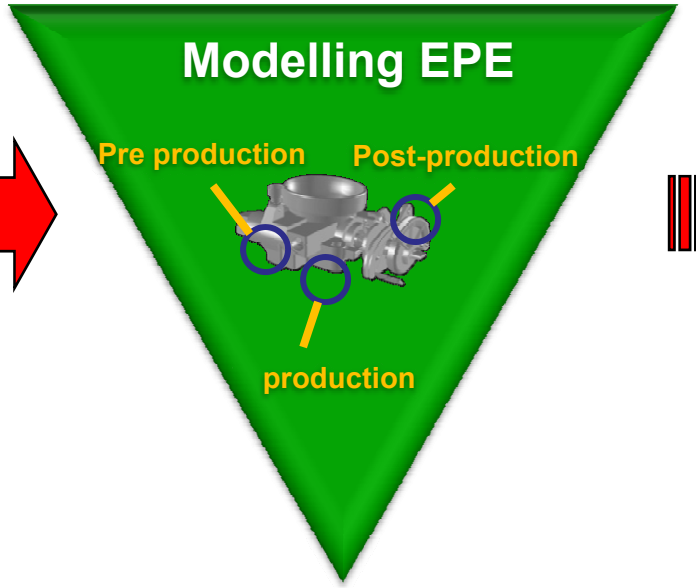


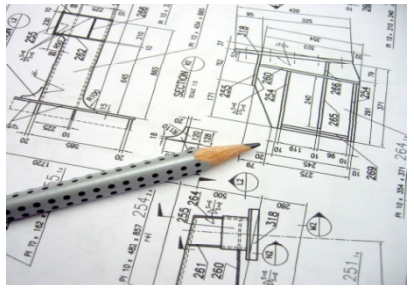
Energy Model for Plant, Process and Product



Modelling Embodied Product Energy During Manufacture







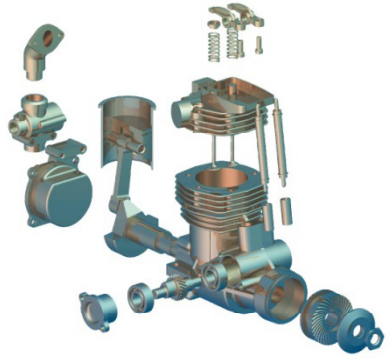
Design for “Energy Minimisation”

An Overview of Embodied Product Energy (EPE)

Research Question & Approach

Research Question

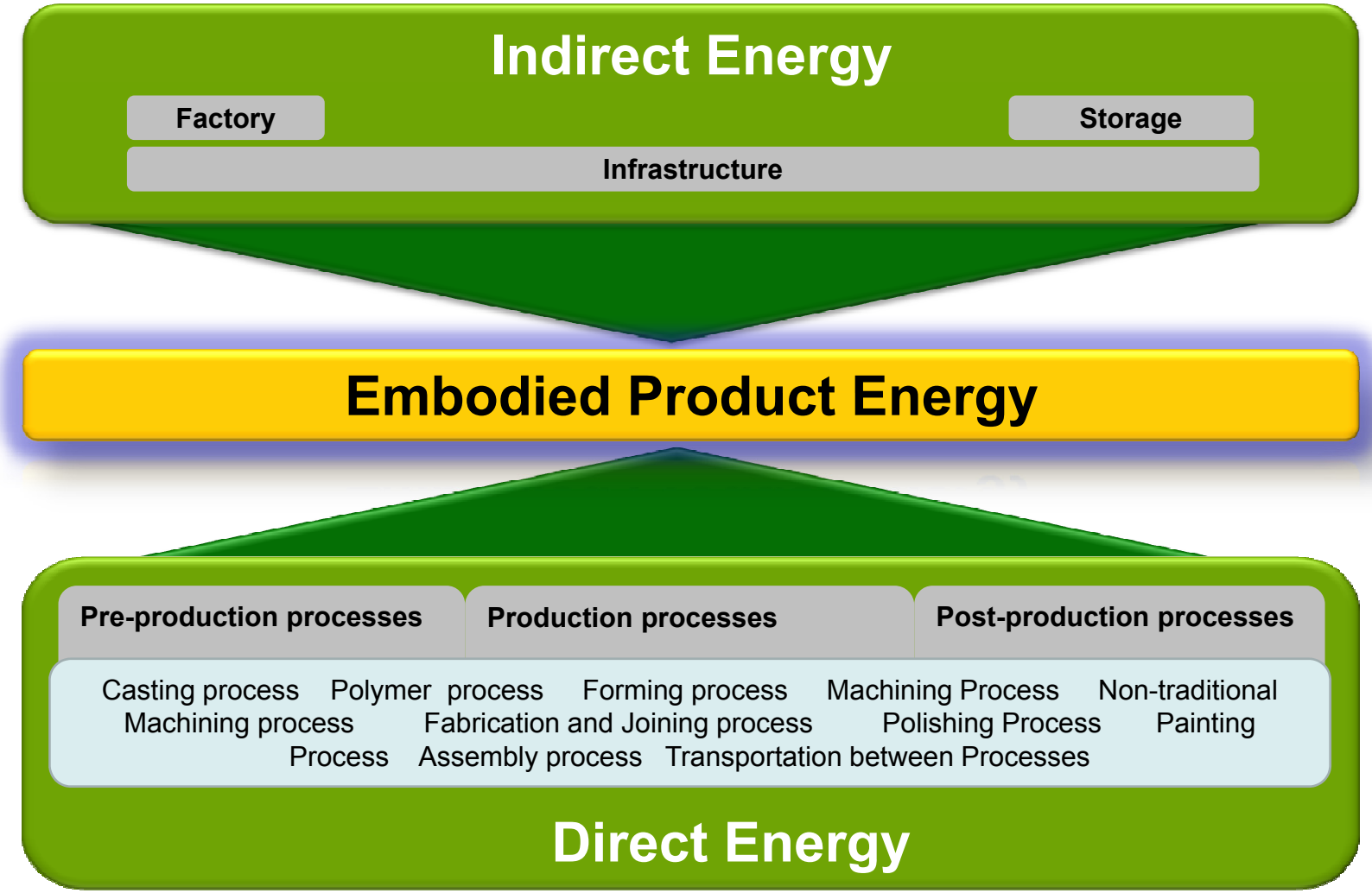
" How much energy is needed to manufacture a unit product ? "



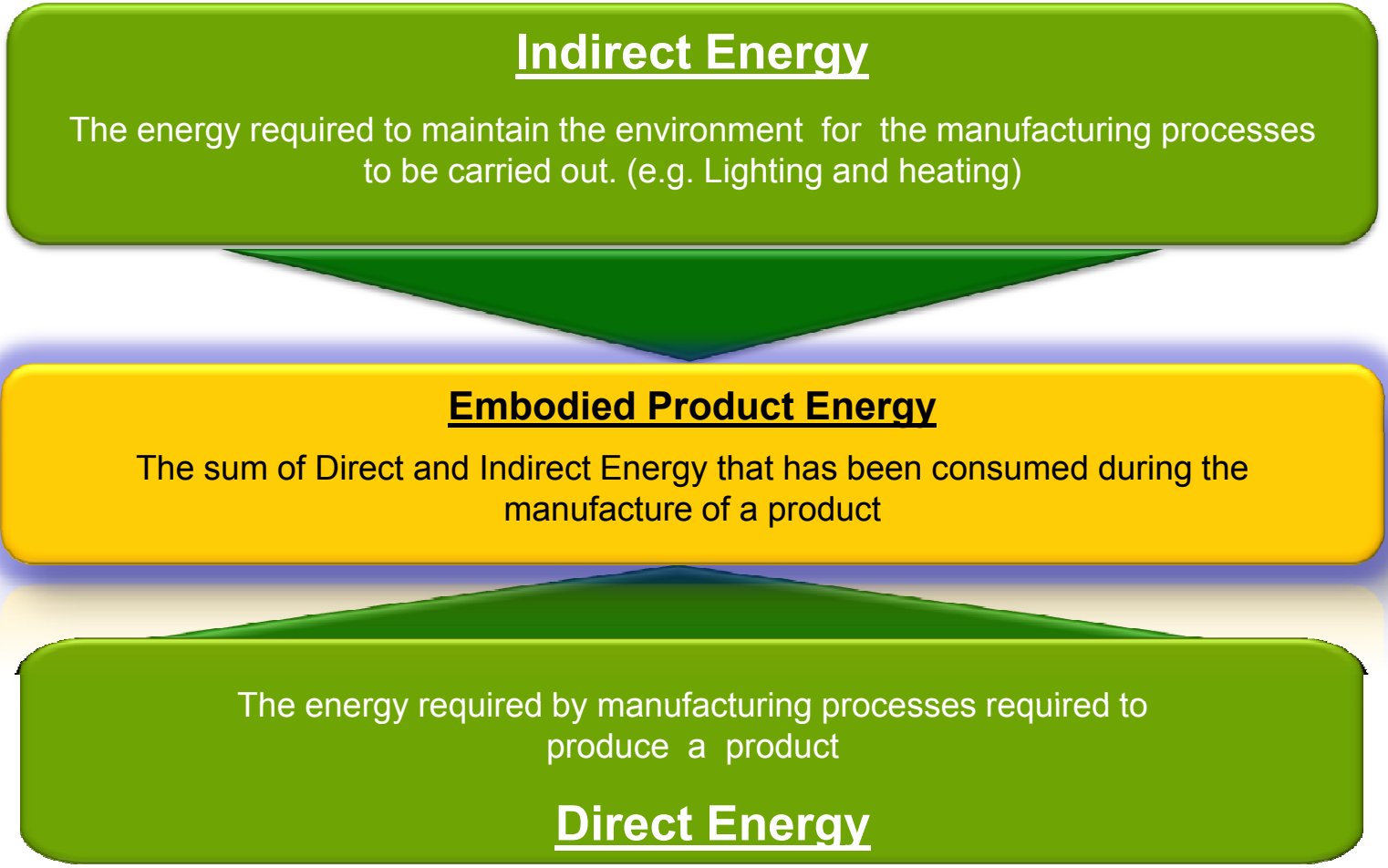
Research Approach

- A model based on the energy used by both the direct manufacturing processes and indirect processes such as lighting and heating should be developed.
- This model must have a level of resolution that provides knowledge on the energy consumption of the individual processes.
- Areas where energy is most inefficient and unproductive can then be identified allowing for optimisation and rationalisation.
- The model will serve as a tool for optimising production efficiency as well as for improving the product design i.e. 'Design for Energy Minimisation'

A Framework to Model Embodied Product Energy



A Framework to Model Embodied Product Energy



Modelling of Embodied Product Energy (EPE)

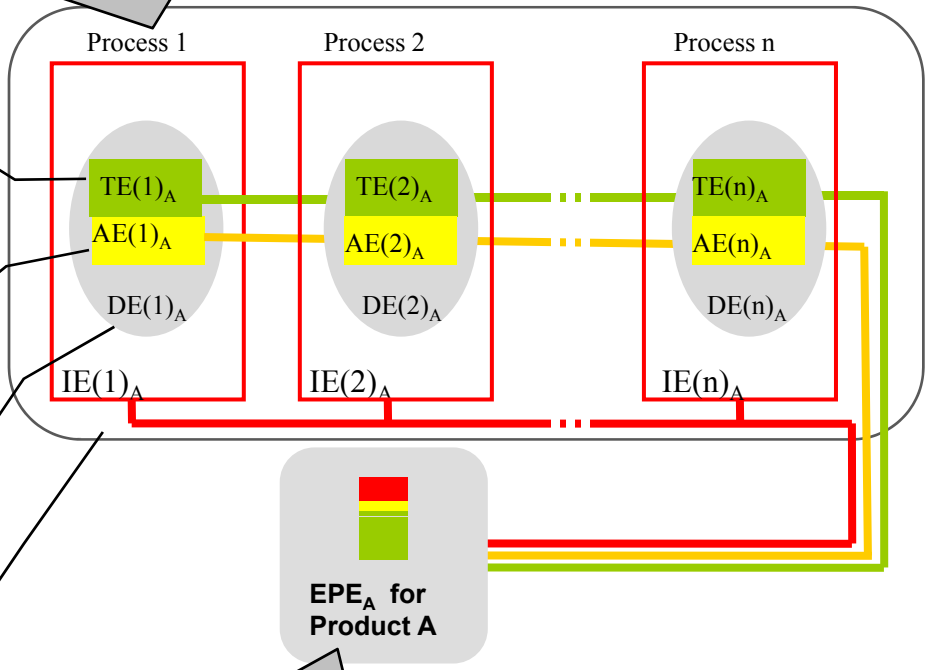
Embodied Product Energy for Process 1 for Product A : $EPE(1)_A = TE(1)_A + AE(1)_A + IE(1)_A$

Theoretical Energy (TE) is the calculated minimum energy required to carry out a process.

Auxiliary Energy (AE) is the energy required by supporting activities to carried out the process (e.g. Control system, Lubricants, coolant, etc.)

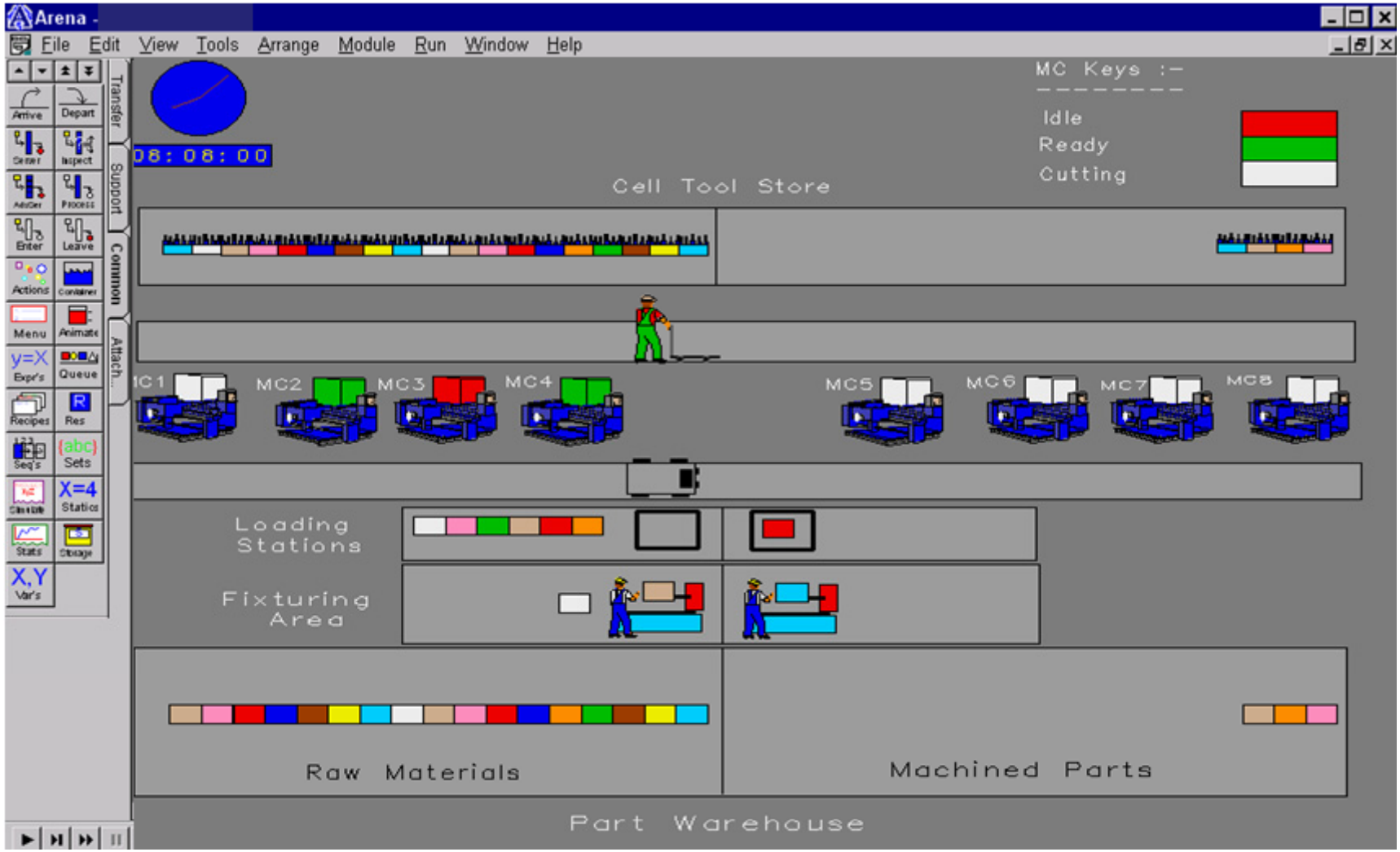
Direct Energy (DE) required by a Process
The energy consumed by activities that are required to manufacture a component

Indirect Energy (IE) is the overhead energy required by a manufacturing environment in which the process is carried out. e.g. Lighting and heating

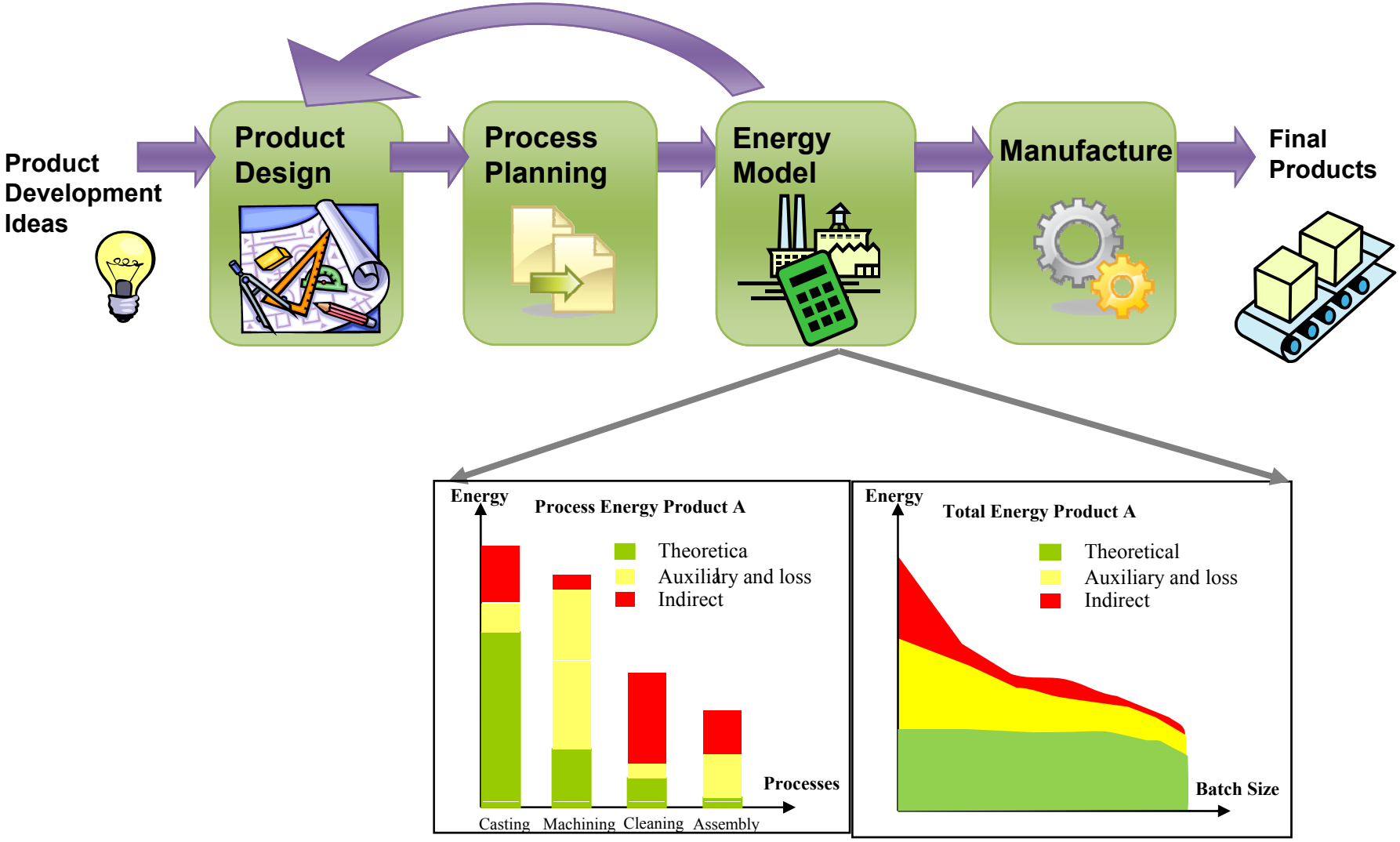


Embodied Product Energy (EPE) for Product A = $\sum_{i=1}^{n} EPE(i)_A$

Energy Simulation Model



Design for Energy Minimisation



Concluding Remarks

- The rapid advancement in renewable energy technologies provides great potential for power generation in the long-term. However in the short to medium term a significant proportion of the electricity will be generated from fossil fuels.
- In this context, the rationalisation of energy consumption will still provide the greatest opportunity for CO2 reduction in the foreseeable future.
- Manufacturing businesses are (and will be) under ever-increasing legislative and economical pressures to reduce their energy consumption.
- The modelling of the Embodied Product Energy enables a “Design for Energy Minimisation” approach to be adopted to reduce energy consumption during the manufacture.
- The EPE Model can also provide increased transparency to the energy considerations within the Life Cycle Assessments of products.

Our Common Future : it is time to make the right choices

"…..let's manufacture a sustainable future ….."

Shahin Rahimifard
TEEM Workshop
October 2009, Stuttgart