RSC Speciality Chemicals Symposium

Sustainable Manufacturing

Profit from the Future

Malcolm Wilkinson

Munich June 2008

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Agenda

- Where are we now?
- Why we need sustainable development?
- How do we specify the journey?
- How do we measure progress?

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The Changed/Changing World

- Globalisation of markets and manufacturing infrastructure;
- Growth in demand from developing countries;
- Climate change and the energy debate;
- Societal and consumer concerns about the health hazards and environmental impact of chemicals;
- Growing awareness of the resource limitations of the planet;
- Regulation and legislation

How Efficient is Chemical Manufacturing?

Sector	Product Tonnage	Kg by-products/ Kg product
Oil Refining	10^6 - 10^8	≤ 0.1
Bulk Chemicals	10^4 - 10^6	1 - 5
Fine Chemicals	10^2 - 10^4	5 - 50+
Pharmaceuticals	10 - 10^3	25 - 100+

Source: R A Sheldon - Delft

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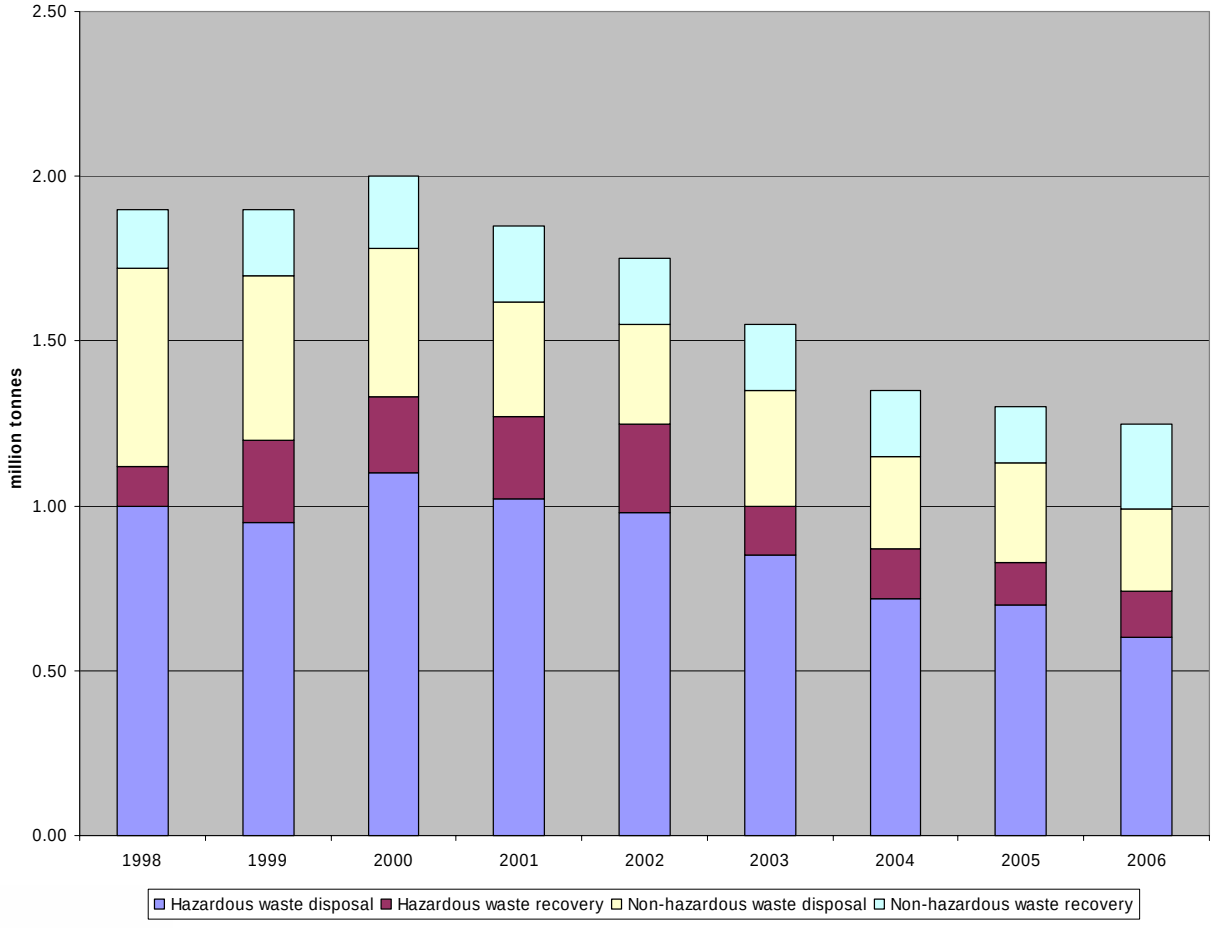
Chemicals Waste Transferred Offsite

Source: Environment Agency



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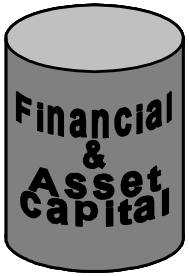
The Five Capitals

Any stock or flow of energy and matter that yields valuable goods and services. It includes resources and sinks. Natural capital is the basis of all production and of life itself.

Comprises all the different co-operative systems and organisational frameworks people use to live and work together
Consists of people's health, knowledge, skills and motivation, all required for productive work.



Reflects the productive power of the other types of capital and enables them to be owned and traded.
Comprises material goods and fixed assets which contribute to the productive process but are not embodied in its output.

Source: Chemistry Leadership Council/Forum for the Future

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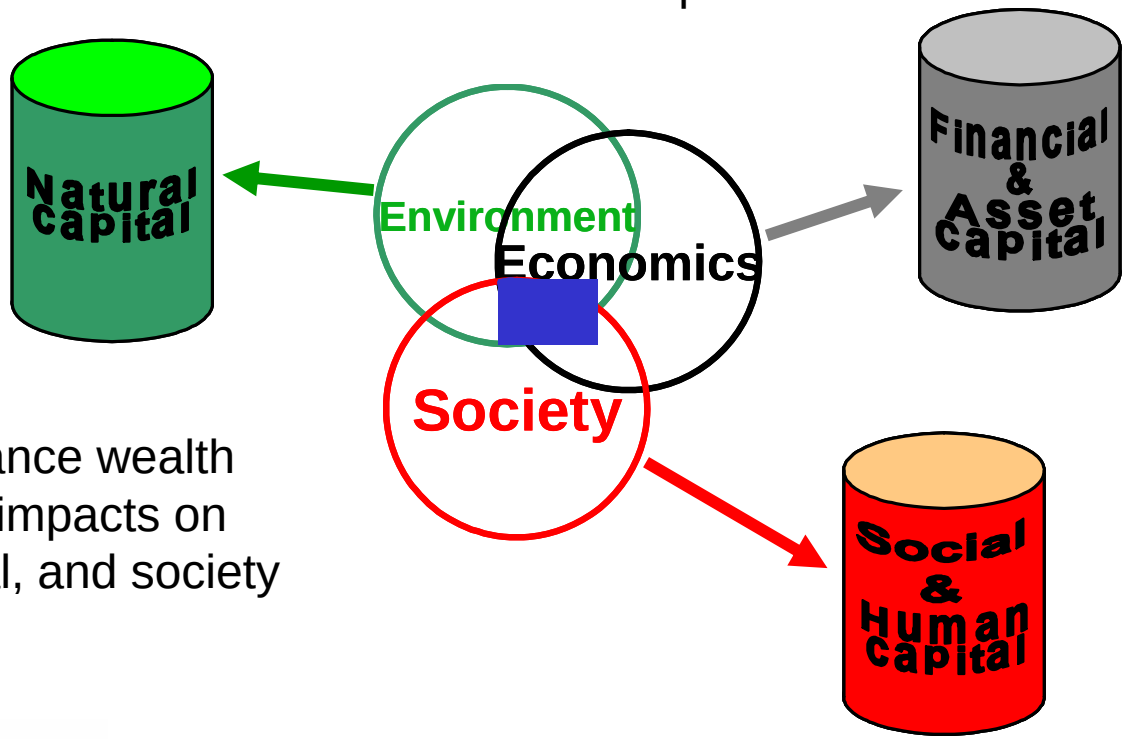
Sustainable Development

Maximising the efficiency of wealth creation is not sufficient for sustainable development.



We must balance wealth creation with impacts on natural capital, and society

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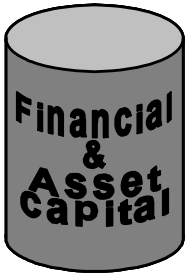
The Business Case

Learning to live sustainably within the limits and carrying capacities of the natural world is a non-negotiable imperative: the process can be delayed, but it cannot be avoided.

The industry's contribution to society goes unrecognised because of its poor reputation. Proactive engagement with local communities, NGO's, media etc is a must. We must explicitly address consumer's concerns.
Pro-active engagement enhances recruitment and retention.



Investors are increasingly concerned to see companies managing their reputation risks. Financial success depends on earning the "licence to operate".
Dematerialisation is the name of the game: more economic value out of less "stuff".

Source: Chemistry Leadership Council/Forum for the Future

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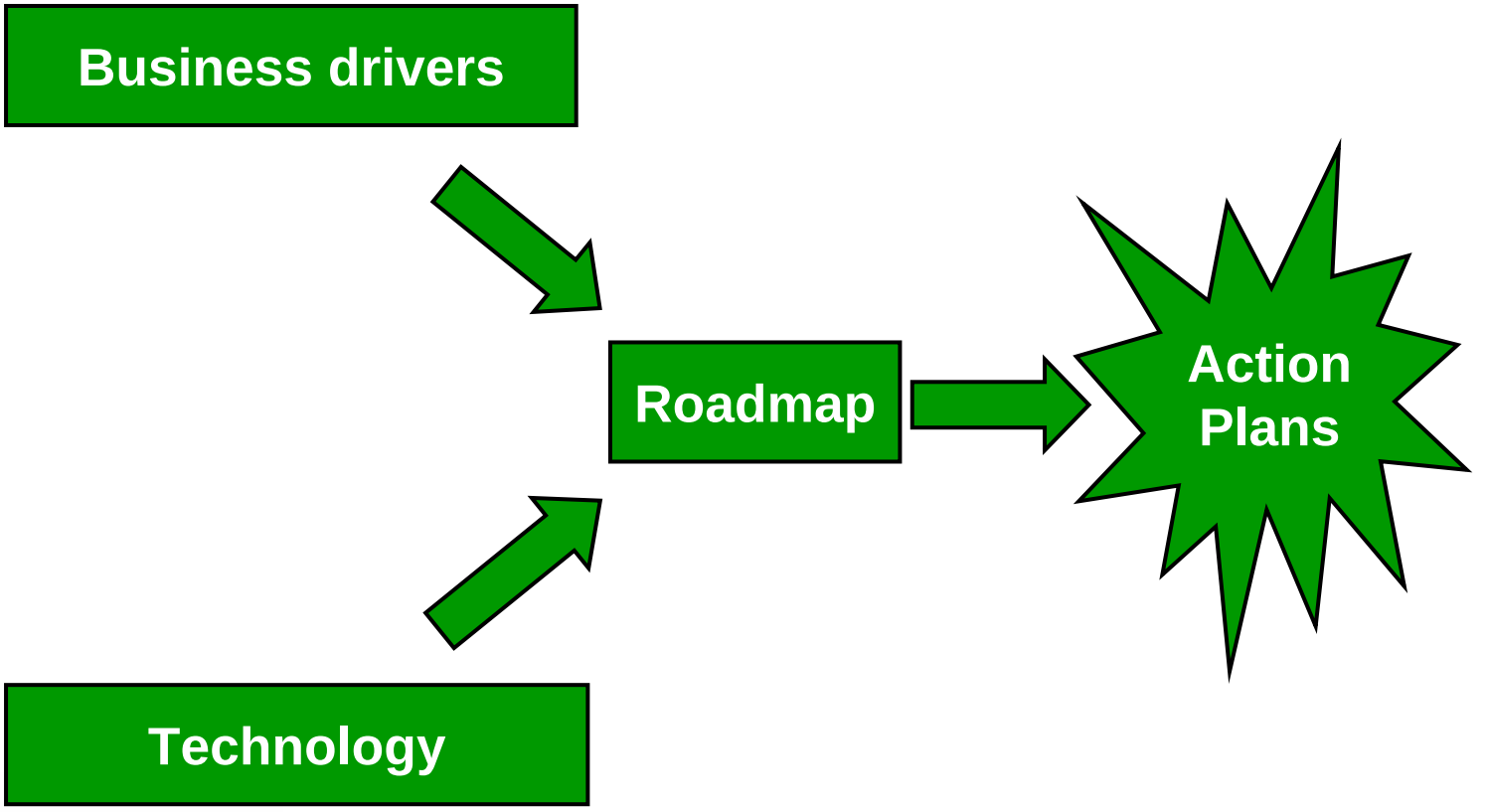
Technology roadmap



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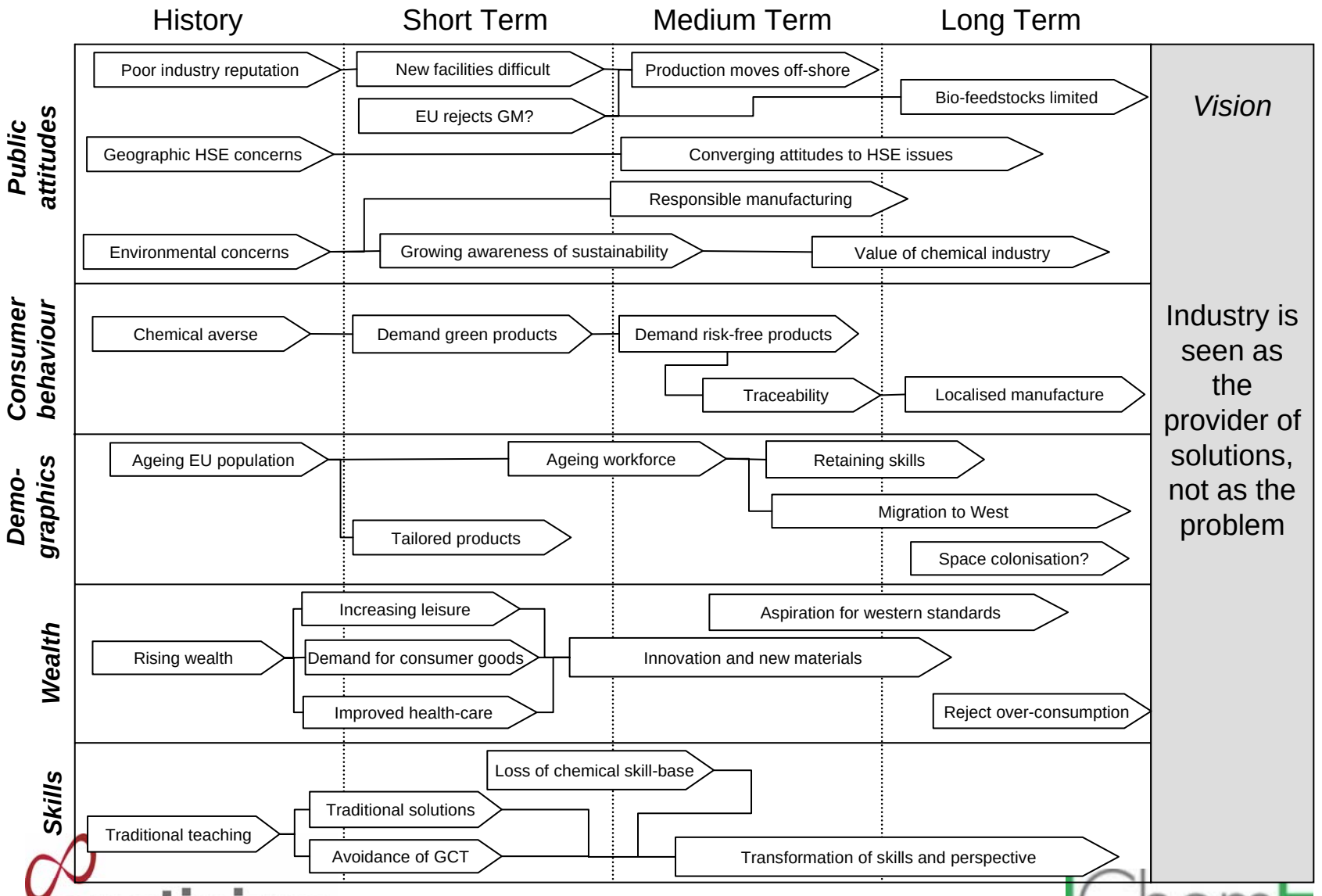

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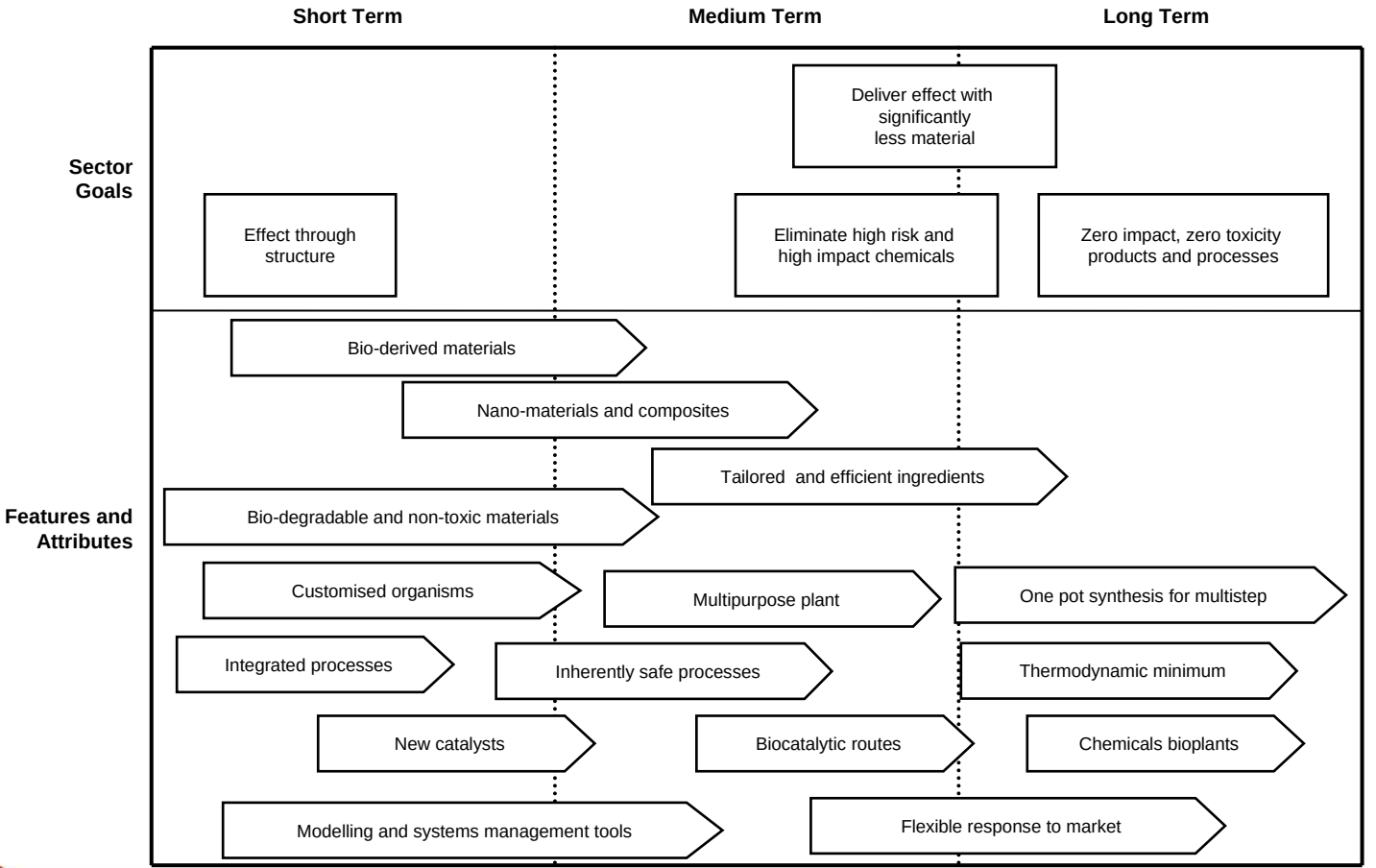
Speciality Chemicals Roadmap



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Challenges

- Zero impact, zero toxicity products and processes.
- Key technology advances centre on:
  - new catalysts including biocatalysts;
  - new benign materials, particularly polymers which facilitate disassembly and recycle;
  - alternative feedstocks using simple molecules, waste and crops;
  - micro and nano materials for enhanced functionality;
  - intensified equipment and a move from batch to continuous small scale processing.
- Need to develop a recognised design approach based on the 12 Principles of Green Engineering.

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The 12 Principles of Green Engineering

1. Inherent rather than circumstantial
2. Prevention instead of treatment
3. Design for separation
4. Maximise efficiency & intensity
5. Output pulled not input pushed
6. Conserve complexity
7. Durability not immortality
8. Meet need, minimise excess
9. Minimise material diversity
10. Integrate material and energy flows
11. Design for commercial afterlife
12. Renewable rather than depleting

Anastas & Zimmerman – Env Sci & Tech, 37, 5, 95-101, 2003

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Essential Requirements of Metrics

- Clear definition of what is to be assessed, and why (Government policy, factory operation, etc)
- the metrics must assess impacts on the different capitals - economic, environmental, societal
- Coverage – key aspects must be included
- Available data – quantifiable empirical data, not qualitative judgements
- Avoid duplication and needless complexity
- Composites if appropriate (recognise weighting problem)

A set of metrics which is not planned for some defined purpose is merely a collection of statistics.

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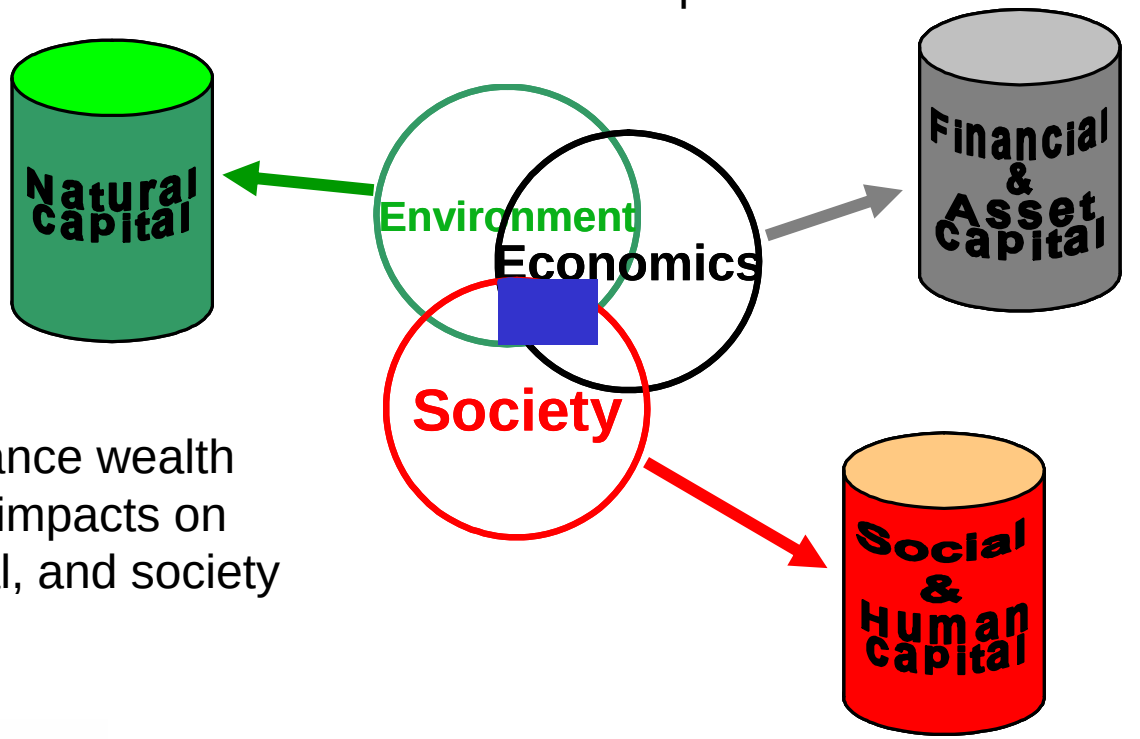

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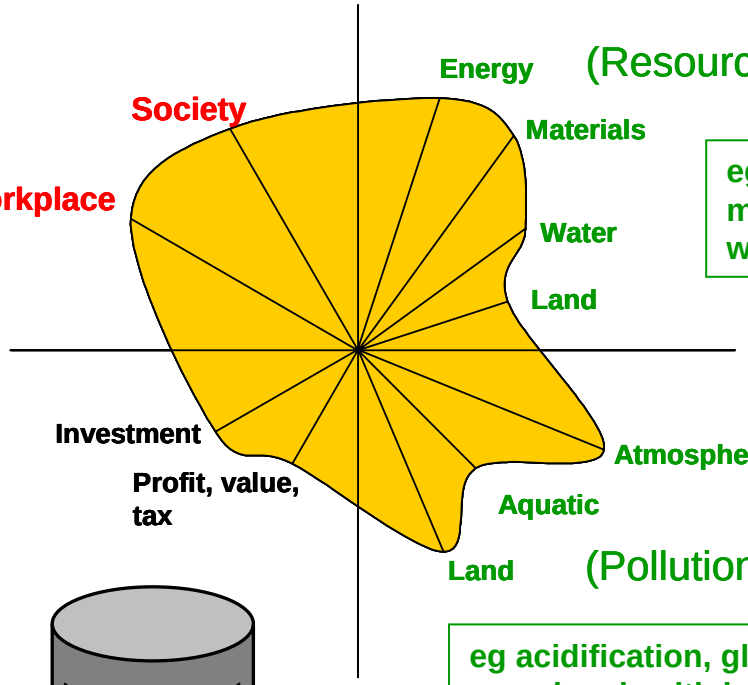
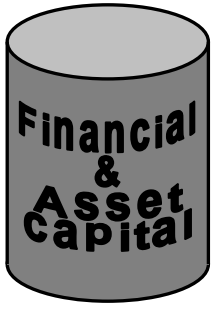
Footprint Measured by IChemE Metrics

eg working hours lost, promotions, wage and benefits package ratio (top 10% relative to bottom 10%),LTA's



eg raw materials used, materials recycled, water, land

eg Value added, margin, NIBT



eg acidification, global warming, health burden, hazardous waste

Source: Darton RC, Trans IChemE B, 81, 2003, 295-302

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Selecting a Set of Metrics

A. Overview of business

B. Definition of Sustainability

C. Definition of system boundary in time and space

The business description in A must include all processes within the boundary

D. Sustainability framework

Analyse business to identify all significant impacts on Sustainability domains - stores of value (capital)
Characterise these impacts with metrics

Source: Aidil Chee Tahir, DPhil Thesis Oxford University

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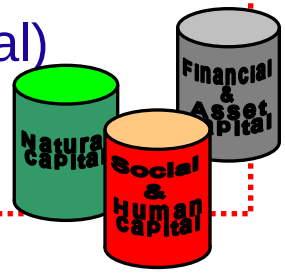
Selecting a Set of Metrics

D. Sustainability framework

1. Sustainability domains
Stores of value (capital)



2. Sustainability perspectives
- *resource efficiency*
- *fairness in benefit/disbenefit*

indicators reflect these

3. Identify Internal Impact Generators
IIG=business process or policy that impacts a store of value

4. Identify issues associated with impact on External Impact Receivers.
EIR=guardian of capital

5. For each issue select an indicator

6. Quantitative measures for each indicator - the metrics

Source: Aidil Chee Tahir, DPhil Thesis Oxford University

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Summary

- More value from less “stuff”; reduce, reuse recycle
- But maximising resource efficiency + the traditional criteria *Fitness for purpose*, *Economic viability*, *Compliance with HSE legislation* are not sufficient for sustainable development; need the 5 capitals
- Roadmapping helps to specify the journey
- A set of metrics must consider *efficiency of using or enhancing capital* and *fairness in distributing benefits and disbenefits* (including inter-generational)
- A set of metrics must assess significant impacts on all types of capital economic, societal and environmental

See www.icheme.org for ICheme Metrics

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