Environmental Engineering & Sustainability

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Outline

- Sustainability.
- Some stages of “environmental engineering”:
  - Environmental impacts.
  - Total life cycle costs & benefits.
  - Life-cycle analysis & system boundaries.

Sustainability

- Brundtland (Gro Harlem Brundtland, Head of commission) report (World Commission on the Environment and Development) (1987): "..development that meets the needs of the present without compromising the ability of future generations to meet their own needs."
- Sometimes criticised for being very human-centred.

Environmental Impacts

- Global warming; greenhouse gases allow energy at short wavelengths from the sun to pass through to the earth's surface, does not allow longer wavelengths from cooler earth to return to space.
- Relative effect of given chemical species on global warming = Global Warming Potential (GWP) = warming potential relative to CO_2.
- Others: water quality (e.g. eutrophication), noise, other air quality parameters, heavy metals, …

Example: Hybrid & Electric Vehicles

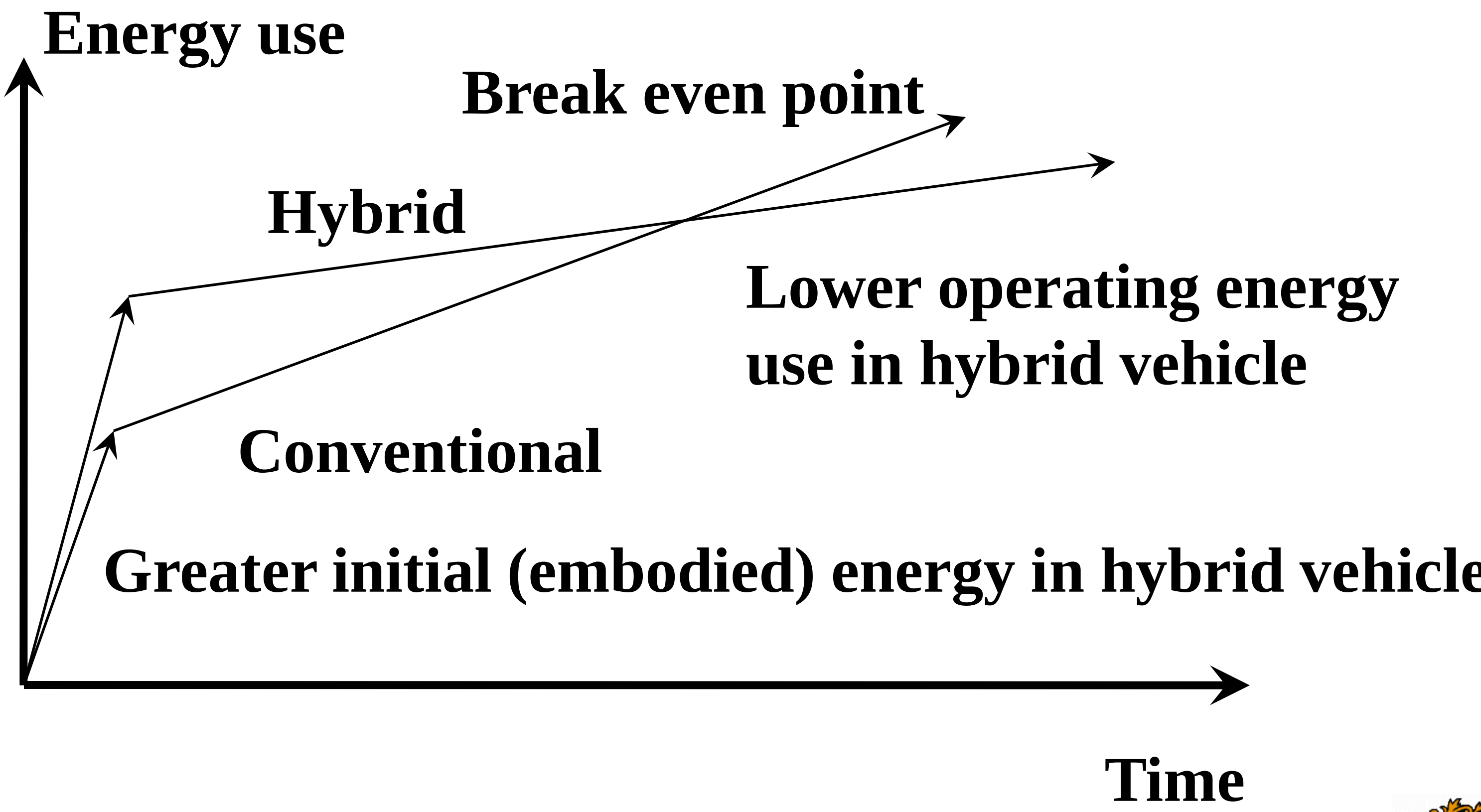
- Combined petrol engine / battery / electric motor, or just electric motor.
- Lower petrol consumption than conventional car.
- Significant embodied energy in battery & components of electric motor.
- Some energy (electricity) used to make the materials (e.g. aluminium) comes from burning coal.
- How environmentally “good” is this?

Embodied Energy

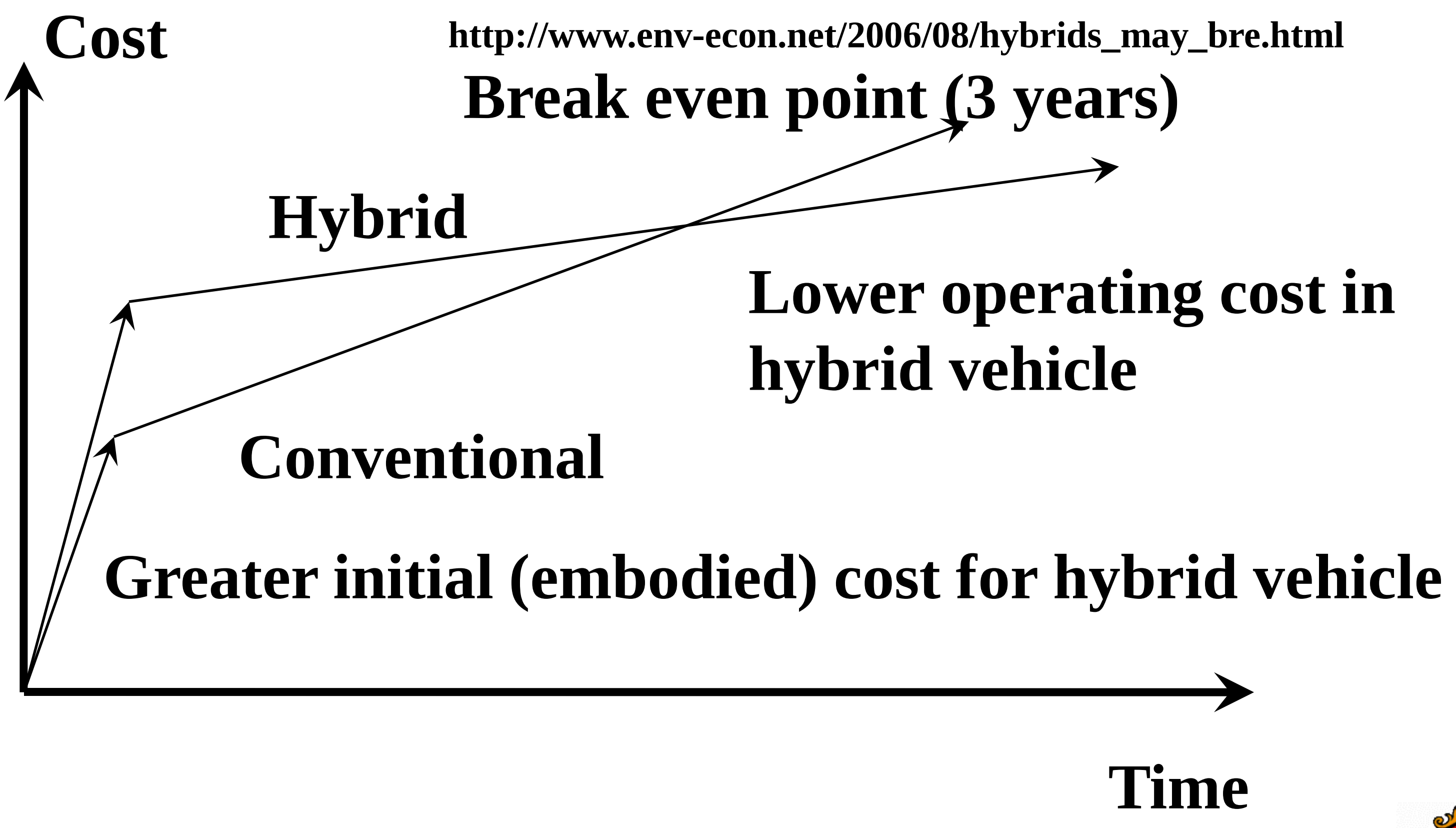
Material	Energy cost (MJ/kg)	Production process
Aluminium	227-342	metal from aluminium ore
Cement	5-9	from the raw materials
Copper	60-125	metal for copper ore
Plastics	60-120	from petroleum products
Glass	18-35	from sand and other meterials
Iron	20-25	from iron ore
Bricks	2-5	baked from clay
Paper	20-25	from timber

Smil, V. (1994). *Energy in World History*. Westview Press. ISBN 0-8113-1901.

Embodied Energy vs Operating Energy



Capital Costs vs Operating Costs



Total Life Cycle Costs & Benefits

- It is no good to have a solution to a problem that "saves energy / minimizes pollution", etc., if it uses an upstream raw material that uses more energy to produce.

	Aluminium	Steel
Energy to produce device	Greater (electricity)	Less
Energy used when operating device	Less	More (heavier)
Overall	???	??

http://www.manufacturingtalk.com/news/ixi/ixi100.html, **Steel versus aluminium - which is 'greener'?, accessed 06/08/2008**

Life Cycle Analysis (LCA) & System Boundaries

- LCA has 4 stages:
  - Definition of system boundary
  - Preparation of emissions inventory
  - Calculation of environmental impacts
  - LCA improvement strategy
- Here, focus on first step = system boundary.

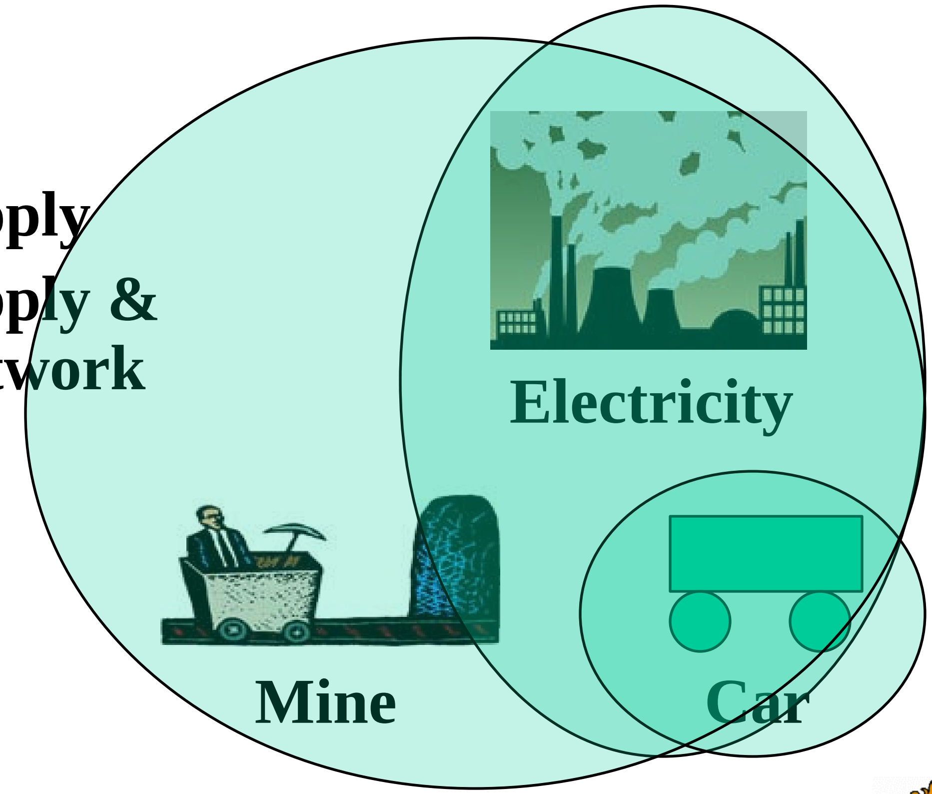
Application of LCA to Example

System boundary?

Car

Car & raw material supply

Car & raw material supply & electricity / petrol network



Some Considerations

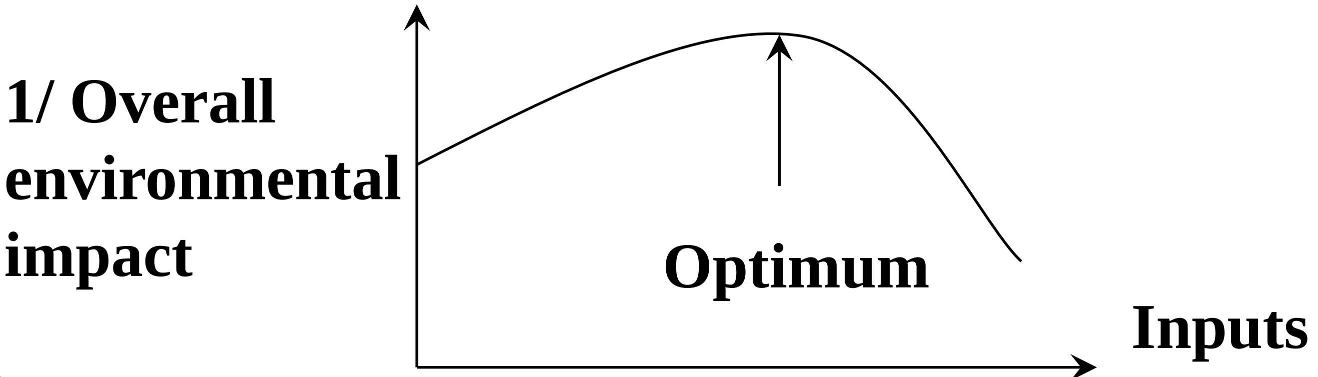
- We really should use the widest possible system boundary to get the most “holistic” (complete) picture of the situation.
- However, this requires a lot of information & time.
- We still need to define a boundary – helps us to measure inputs & outputs for economic purposes anyway.

Another Example: Pollution Abatement

- Problem: remove toxic gases from gaseous emissions from (say) car painting operation.
- **How?** Separate toxic gases from non-toxic gases in “scrubber”.
- **More scrubbing, cleaner gases, but more energy & materials to do scrubbing.**

Optimum Degree of Abatement

- Increased capital & operating inputs required to improve pollutant removal.
- Increased inputs = increased wastes.
- Hence trade off exists.



Conclusions

- Trade-off between embodied energy & operating energy (like capital & operating costs).
- Optimal degree of abatement at non-zero emission level, where overall environmental impact is minimized (could be guideline to legislators when setting discharge limits).
- If the optimum level > regulated levels, then regulated levels are costing more & doing more environmental damage.

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