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IMPROVING ENGINEERING EDUCATION

What do engineers need to learn about sustainable development?

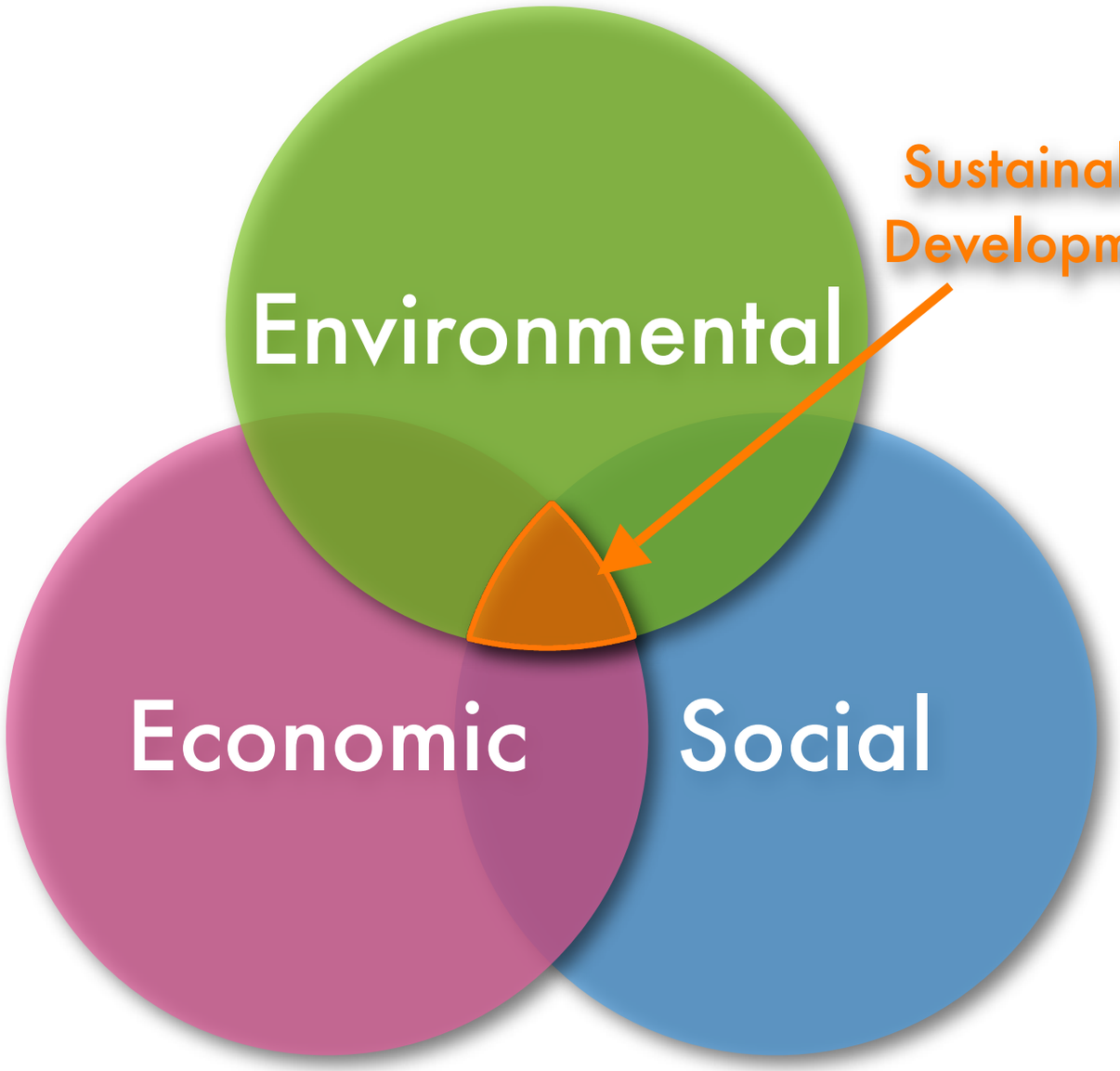
The Cambridge-MIT Institute

UNIVERSITY OF CAMBRIDGE

Notes

- This slide show is based on a lecture originally given by Charles Ainger, developed under the Royal Academy of Engineering's Visiting Professors Scheme. Updated and modified by Dr. Sue Jackson, ImpEE Project, Department of Engineering, University of Cambridge.
- Version 2, November 8th, 2005

Engineering Sustainable Development aims to balance the three elements:



- **Economic:** what things cost - and how to make a business out of providing infrastructure, goods or services
- **Environmental:** what impact those things have on nature and the earth's support systems - which are finite
- **Social:** how those things serve the needs and quality of life of people and their communities

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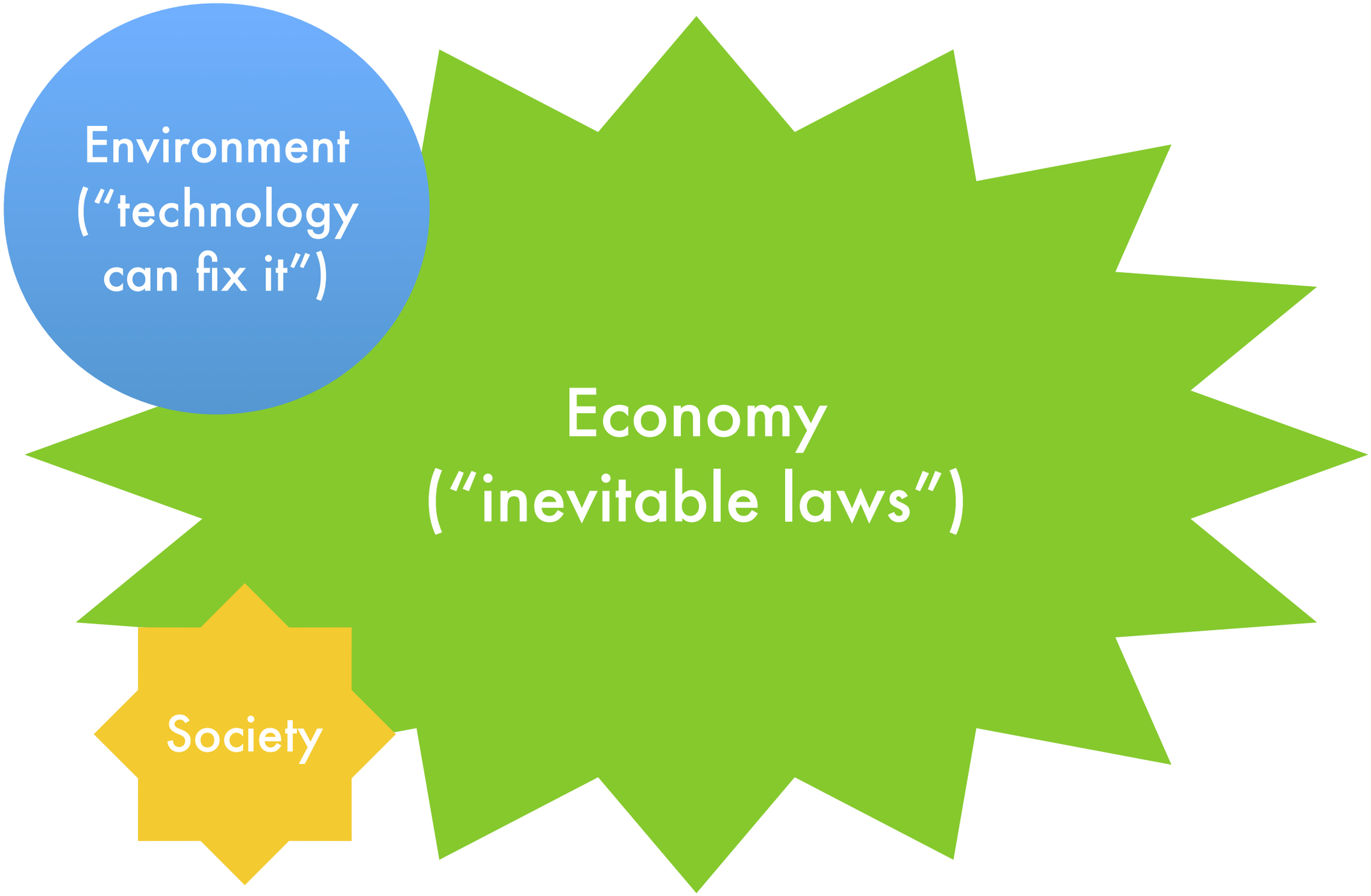
- The concept of sustainable development involves all three aspects of a project equally. i.e. the environmental, the social and the economic. It is not enough to consider environment alone. This is often referred to as the 'Triple bottom Line'.
- The triple bottom line is shorthand for environmental protection, economic development and social progress. Social equity issues are particularly challenging for engineers to get to grips with.
- Sustainable development is often represented by showing these three dimensions as a Venn diagram with sustainable development as the overlapping segment in the middle. What this shows is that a balance between the three elements is required. However this can also imply that some aspects are beyond sustainable development considerations.

The current world view - relative importance?



Notes

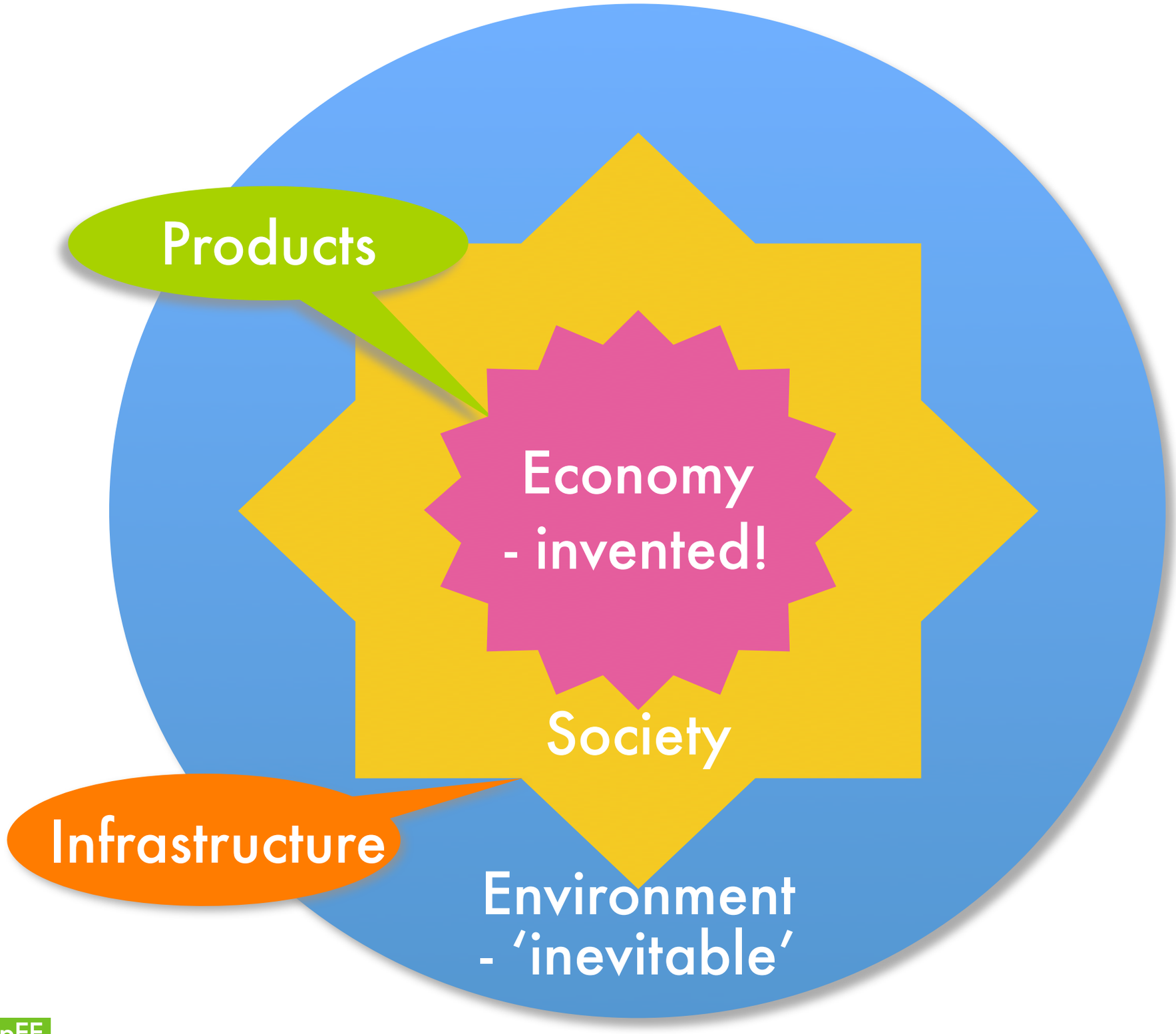
- This slide illustrates the relative importance currently placed on the three factors.
- The economy is seen as being the major factor for consideration and is sometimes perceived as having 'inevitable laws'
- The environment is viewed as serving into this in terms of provision of goods (resources) and Services (waste assimilation). Often this view is accompanied by a belief that 'technology can fix it'.

But *this* is what we all ultimately depend on for life - so...

Notes

- Picture from NASA.
- The Apollo missions of the late 1960s and early 1970s profoundly changed the way that people perceived the world on which we live. Previously, the Earth has seemed vast, and powerful. Human activity seemed weak in comparison and it was widely accepted that we could do nothing that would significantly affect the planet. Concepts such as 'dilute and disperse' for wastes perpetuated in this climate.
- The images of the Earth from the space missions brought about a new perspective (like this one showing the Earth from the Moon). Now we could see our home planet looking small (obviously finite) and rather fragile in the vastness of space. This profoundly changed the way we think about the environmental system and this is reflected in changes in popular environmental thinking around that time.
- See also, books such as Rachel Carson's "Silent Spring" published in 1962. Link: http://onlineethics.org/moral/carson/

Engineers provide the interfaces…



- Becoming sustainable requires leaders who recognise this world view, and act accordingly.

- Therefore - ***engineers can't be neutral*** - we are either making things better, or worse

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Notes

An alternative way of looking at the world is conveyed in this figure:

- Environmental laws are 'inevitable' – they are the laws of nature. The environment nurtures, supports and makes possible.
- Society has a mixture of instinctive and learned/cultural laws.
- Economy has rules and practices which are totally 'invented' by society. So why do so many regard Economic laws as 'inevitable' (globalisation, etc) but Environmental laws and limits as manipulatable?

Engineers' designs have a *critical sustainability impact:*

- "by the time the design for most human artefacts is completed….80-90% of their life-cycle economic and ecological costs have already been made inevitable"
- Or, in design:

  "All the really important mistakes are made on the first day"

"Natural Capitalism" - 1999

So: to lead sustainable development, engineers must think differently - use a different design mentality - from that first day

Notes

- Hawken, Paul, Lovins, Amory B. & Lovins, L. Hunter (1999). "Natural Capitalism – The New Industrial Revolution " Earthscan, London.
- Engineering for sustainable design is an integral part of modern engineering culture.

- Over the last 50 years, 'development' - comprising engineering projects, and products - has benefited large numbers of people, world wide……*but:*
- The way we have been doing our development is often "unsustainable" - in social and environmental terms
- This leads to real fears about the security and quality of life that my children, and grandchildren - and yours - and the world's - can expect

"We do not inherit the earth from our ancestors - we borrow it from our children"

(Anon – Native American Indian)

Notes

- The Native American Indians have a theory of seventh generation responsibility – three generations either side of ourselves, e.g. We have a responsibility for the impacts our actions will have on our great-grandchildren.
- Three generations forwards equates to around 100 years– a similar scale to things like climate change predictions.

Sustainable Development is the journey *towards* Sustainability

Global Society in 2005: Unsustainable

Sustainable Development

A Future Sustainable Society

inequality, much poverty left; threat of decreasing quality of life

basic needs and life quality provided; tolerable inequality; living within the Earth's limits

Notes

- This illustration is advocated by Forum For the Future and is useful for stressing the concept that sustainable development is a route towards a better future rather than trying to predict a Utopia. Sustainable development is the path towards a sustainable future society.

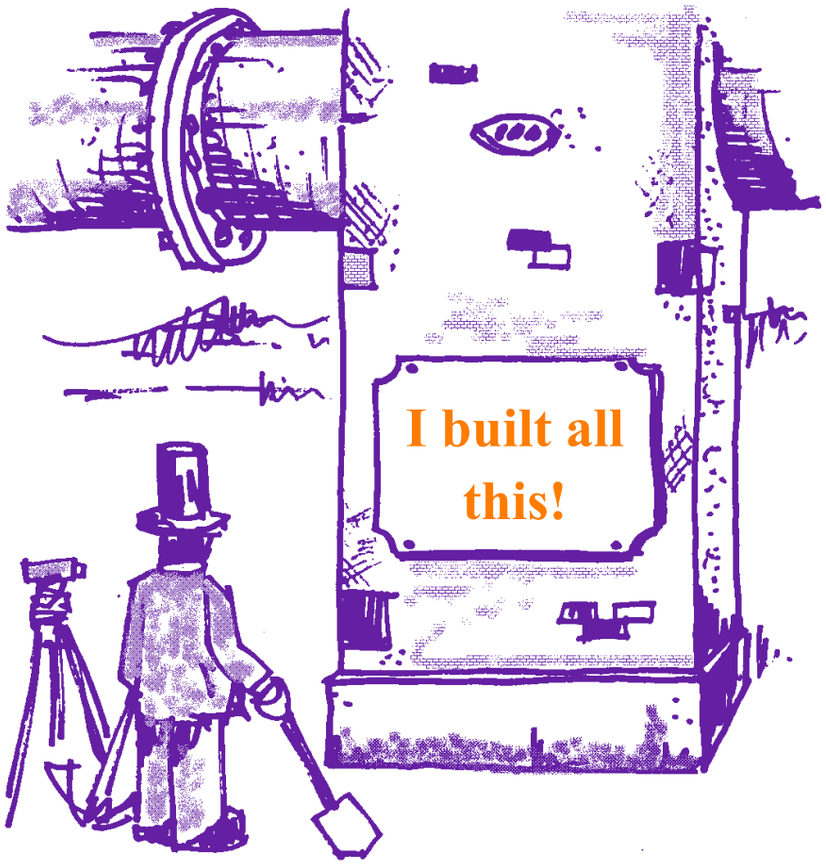
Link: http://www.forumforthefuture.org.uk/

What should engineers be doing about it?

- Choosing Technology
- Understanding the environment
- Appreciating the social challenges in making it happen

We need new challenges - redefine engineering culture away from "Building things"

The 19th (& 20th?) Century Engineer



Visible construction, at great public expense, to meet society's wants

The 21st Century Engineer

Providing and Refurbishing the minimum to meet society's needs

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- "This cartoon summarises why it is particularly hard for engineers to accept the changes required. The older ones among us know the ideal of going into engineering in order to finish up with some large structure with your name on it. My first cooling tower has my initials in the concrete on the top! Now, I realise that my cooling tower, that I put too much effort into, is DESIGNED to waste 70% of the value of the original fuel... Many of our younger engineers and technicians are being very efficient, and sustainable – helping client solve problems in cleverer ways using fewer resources, as well as lower costs." – Charles Ainger.
- " When building big and new no longer serves society's needs, engineers need a new challenge – I suggest that could be much higher energy and materials efficiency." – Charles Ainger

A huge new technical challenge: - *energy and materials efficiency*

We can drive materials efficiency:

- "600 tonnes of material are used to make 60 tonnes of product of which 6 tonnes are in use 6 months later"

(Lord Sainsbury, Minister for Science and Industry)

We can drive energy efficiency:

- "The whole economy is less than 10% as energy-efficient as the laws of physics permit"

(From "Natural Capitalism" 1999)

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Notes

- First quote by Lord Sainsbury, Minister for Science and Industry "The Engineer for the 21st Century Inquiry", Forum for the Future, 2000.

Link: http://www.forumforthefuture.org.uk/

Which of these is worth more of an engineer's purpose, energy & interest?

"Video toothbrush"

In development by Panasonic, this electric toothbrush has a miniature video camera mounted beside the bristles to allow the user to see on a monitor the '40%' of debris they normally miss."

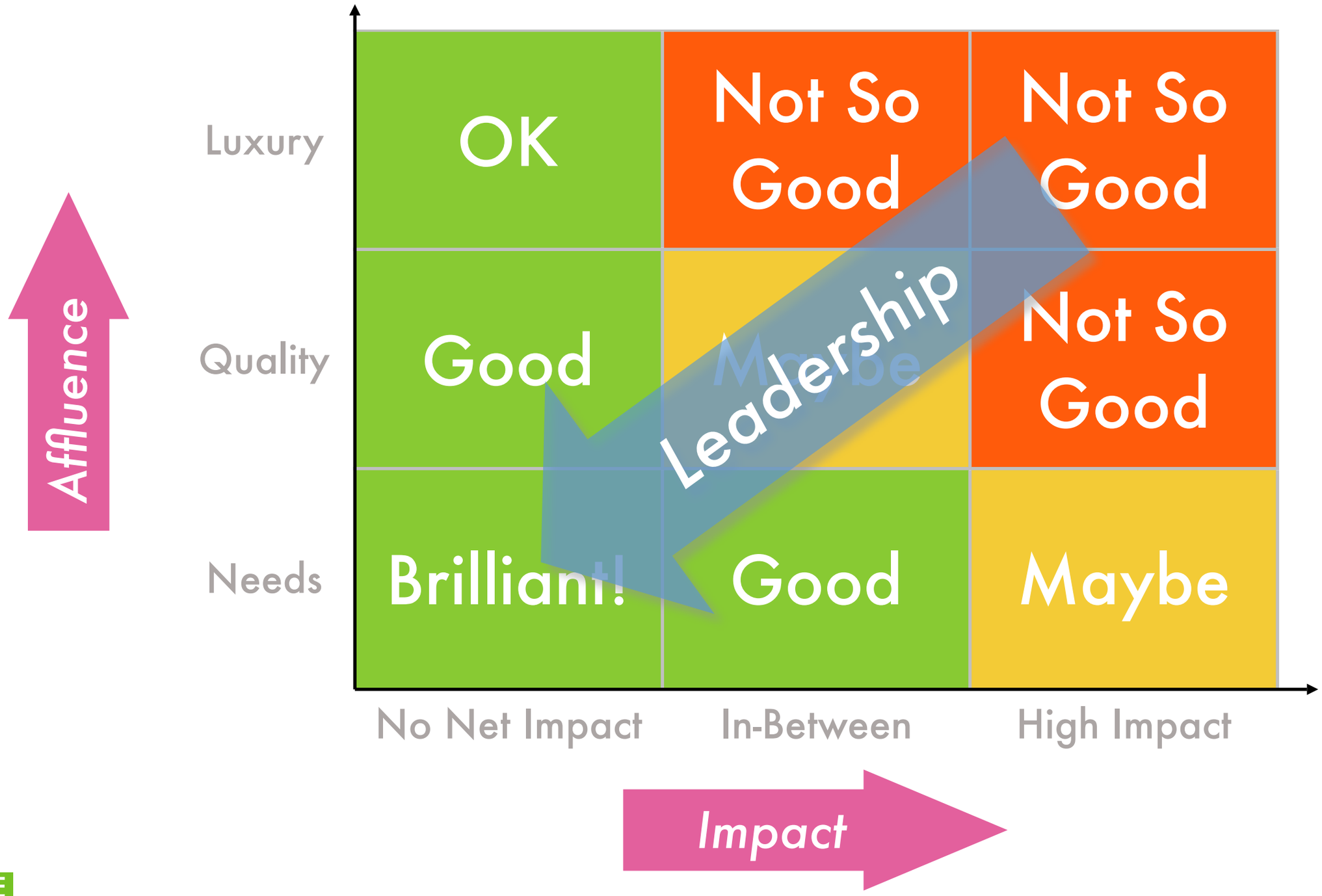
(TYNKYN - EC 11/01)

Rachel Battilana - refugee tent linings - 2001 Young Engineer of the Year

Notes

- Rachel Batilana was a structural engineering undergraduate at Cambridge University who chose to use her considerable engineering talents to tackle a problem more concerned with global issues than with highly profitable technology development.

Choosing what you are engineering for - engineers can't be neutral



Notes

- Engineers carry out projects that can range from low environmental impact to highly environmentally damaging, and also from those that meet basic needs to those that develop a market of luxury goods. It is the engineer's personal choice where they decide to put their efforts but for sustainable development maybe we should be aiming for low impact projects that meet a need, rather than creating luxury products aimed at the affluent consumers that create a 'want'.

A new approach

- Sustainable development is NOT about doing things we are doing now, but doing them "less bad".
- It IS about designing and producing products we need for a growing and prosperous society that are actually good.

Bernard Bulkin, Chair of the Sustainable Development Commission

Notes

- Quote from a speech by Bernard Bulkin, Chair, Climate Change, Energy and Transport,Sustainable Development Commision, presented to the Royal Academy of Engineering at a special meeting on 6 September, 2005.
- Attributed to Bill Mc Donough, co-author of the book "Cradle to Cradle -remaking the way we make things." By William McDonough and Michael Braungart, North Point Press, 2002. McDonough and Braungart make the case that an industrial system that "takes, makes and wastes" can become a creator of goods and services that generate ecological, social and economic value.

Link: http://www.sd-commission.org.uk/

The environment is unknowably complex. We need a "paradigm shift" in how we think about it...

Mechanistic World	→	Systemic, Complex World
Newtonian Mechanics	→	Chaos and Complexity Theory
Independant, linear, cause and effect	→	Interconnected, feedback loops
Predictable outcomes	→	Uncertainty; patterns within disorder
Arrogance over nature	→	Humility, within nature
So - technology can remove "natural" limits	→	Maybe, *but not affordably, nor with predictable outcomes*
Hence - narrow, blinkered, technical solutions	→	Hence, *analyse systems holistically; understand feedback loops; apply the "Precautionary Principle"*

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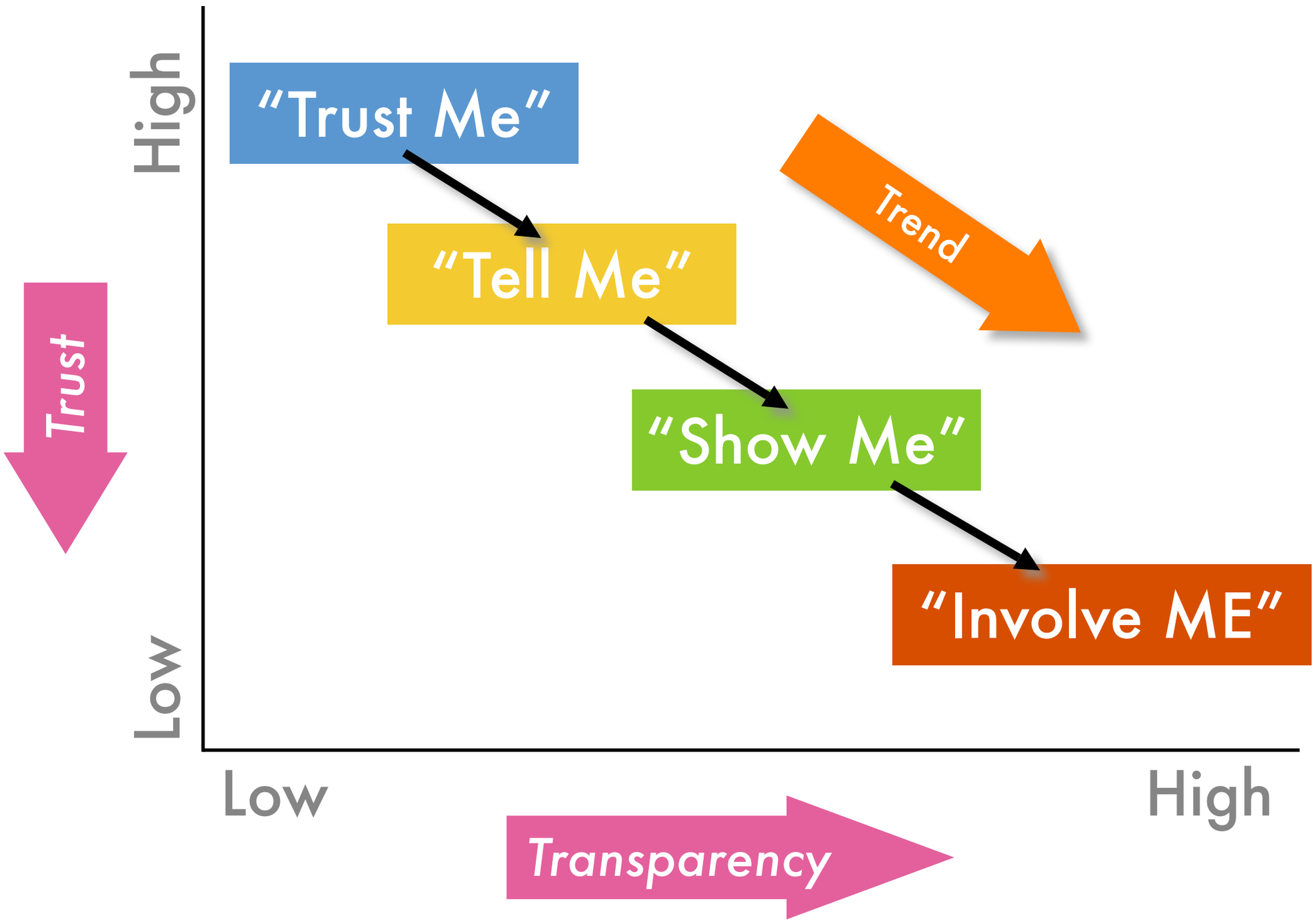
Consultation - Society's Changing Expectations



Notes

- In the past, society has been more willing to trust an expert and have tolerated low levels of corporate transparency. However, in recent years the trend has been towards more transparency and involvement and with it less reliance on trusting the 'experts'. In general the move has been through "tell me what you are doing" to "show me what you are doing" and is now heading more frequently to "involve me in what you are doing".
- For example, if an oil company wanted to indicate that they were protecting the environment, in the past, they just needed an expert with a high enough level of trustworthiness to inform the public and be believed by them, later generations did not trust the experts due to failures and loss of trust so have demanded more involvement, they may have asked initially for details of the protection measures, and later still evidence of the success of such measures. Now they may even want to be involved in deciding what environmental elements should be protected and how. *Rein Willems, Exec. VP, Shell Chemicals: 3rd Middle East Refining and Petrochemicals Event; Bahrain, 31/10/01*

‘Social’ components can help deliver sustainable solutions

Local community ownership:

- 70% local co-operative ownership seems to be the key to Denmark’s success in avoiding ‘NIMBY’ for wind farms - ~ 10% of Danish power
- UK, wind farms are almost entirely private corporation owned, and overall market penetration is less than 0.15%

Is there any connection?

Notes

- NIMBY stands for 'Not in my back yard'.
- Inventing the technology is not enough: public acceptance is an important issue. An understanding of what makes people accept a technology can make a huge difference.
- In the UK there is a huge resistance to wind farms. They have been successfully introduced in Denmark by involving the community. Co-ownership means that the community directly benefit from their introduction.

Engineers need to learn to engage better with communities, to implement the complex solutions that sustainability needs

Technical Complexity:

We are developing the GIS, data handling and modelling to deal with geography, physics, chemistry ,and even with the uncertainties of biology

Social Complexity:

Now we also need to engage with the community, and develop the capability to consult, facilitate and agree on the complex solutions.

This needs new engineering skills

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What do *you* think?
- do you agree, or not?

- Should engineers be concerned with the 'purpose' and social dimensions of technology application?
- Is all this soft 'society' stuff not a proper subject for 'real', scientific engineers?
- How well do we really need to understand the environment?
- Can we extend our professional 'ethic' to include the environmental and social consequences?
- Can engineers take a lead in ESD – and would this encourage more young people to be engineers?

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- ESD: Engineering for Sustainable Development

‘The Engineer of the 21st Century’ - some of the outputs:

- “Individual engineers should understand their personal ethics and values and those of their employers if they are to recognise those of others and influence change.”
- “Our vision is of an engineer who **demonstrates** through everyday practice:
  - an **demonstrates** of what sustainability means
  - the **demonstrates** to work towards this aim
  - **demonstrates** that relate to their wider social, environmental and economic responsibilities
  - and encourages and enables others to learn and **demonstrates**”

Conclusion…?

- *So: we are not (yet) educating our engineering graduates to deal with the key issue of the 21st Century*

Engineers can invent a sustainable future?

"We are all part of the continuum of humanity and life. We will have lived our brief span and either helped or hurt that continuum and the earth that sustains all life. It's that simple.Which will it be?"

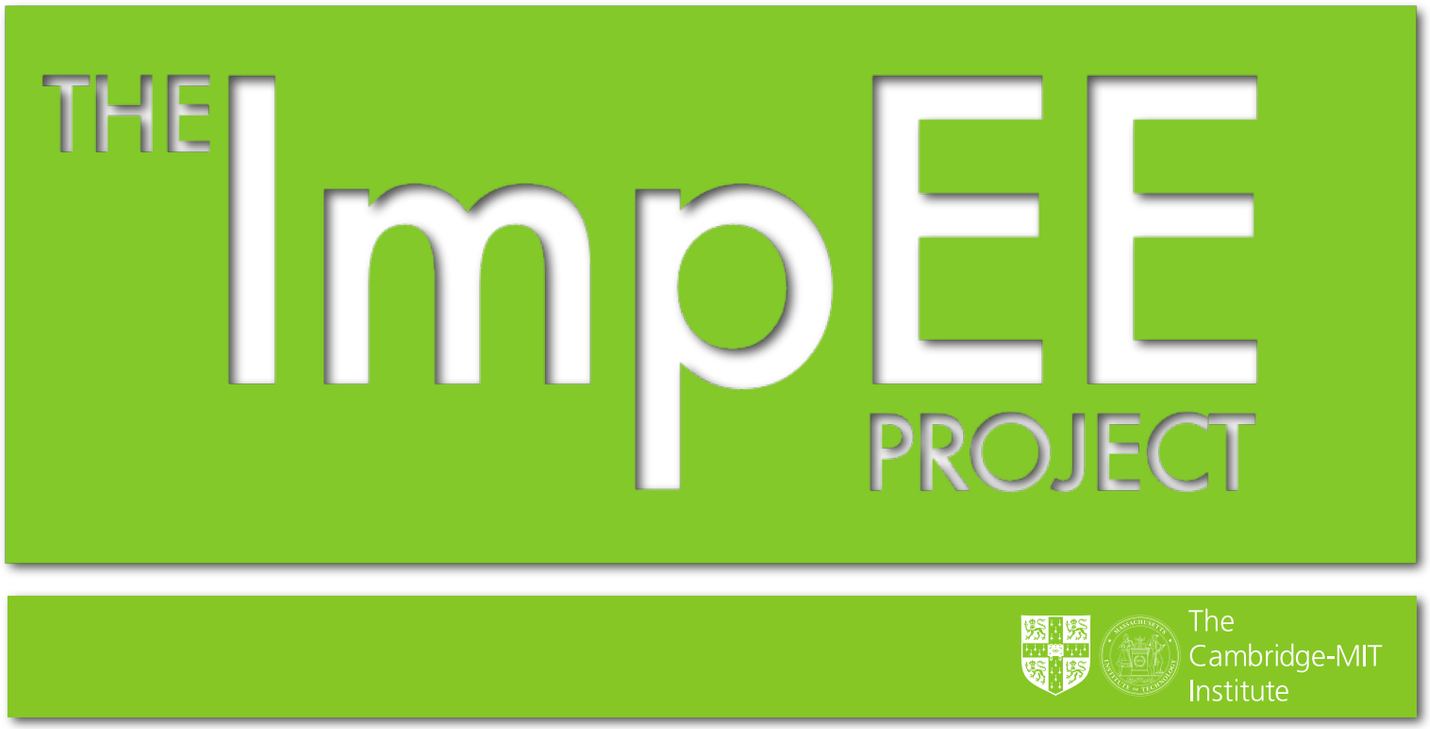
Ray Anderson, Interface Carpets - to other CEOs

"The best way to predict the future, is to invent it"

Alan Kay, Apple Computer

Notes

- Ray Anderson, Founder of Interface Carpets, has embarked on a mission to "be the first company that, by its deeds, shows the entire industrial world what sustainability is in all its dimensions: People, process, product, place and profits – by 2020 – and in doing so, to become restorative through the power of influence." Today, Ray is recognized as one of the world's most environmentally progressive chief executives.



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