



Context, Framing, Risk, Uncertainty, and Integrative Approaches to Complex Sustainability problems



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1. Framings and Sustainability
2. Competing Paradigmatic Conceptions of Reality
3. Engineering Implications
4. (New) Engineering Approaches
5. Case Study; Building in the Human Element

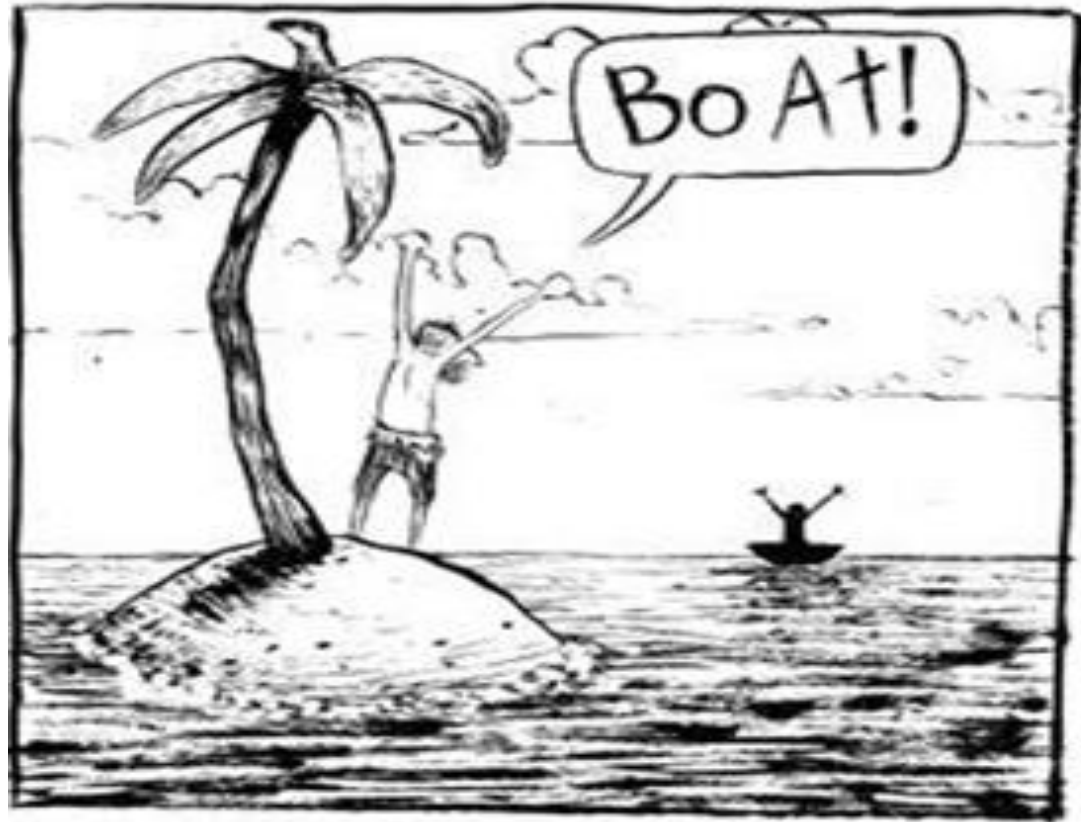


1. Framings and Sustainability..



Is our society sustainable?

..on what basis do you say this??





Framing is crucial for our understanding of Reality

Different perspective from different frames may yield:

- Different truths

- Partial truths



- Delusional perceptions of reality (untruths)



Single View

Multi-View



- Half truths

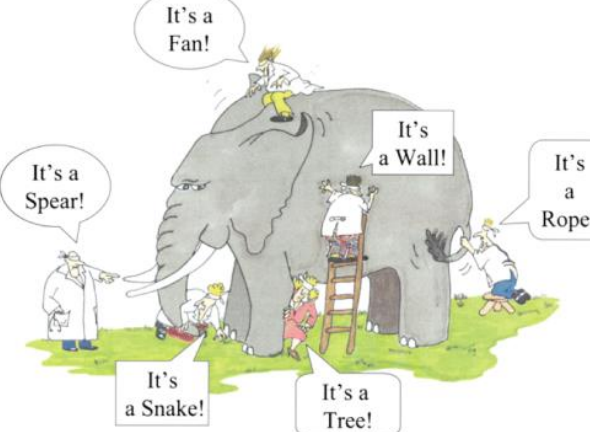
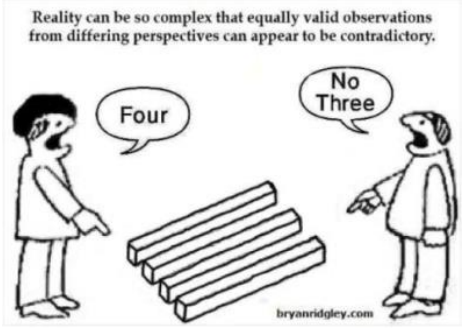
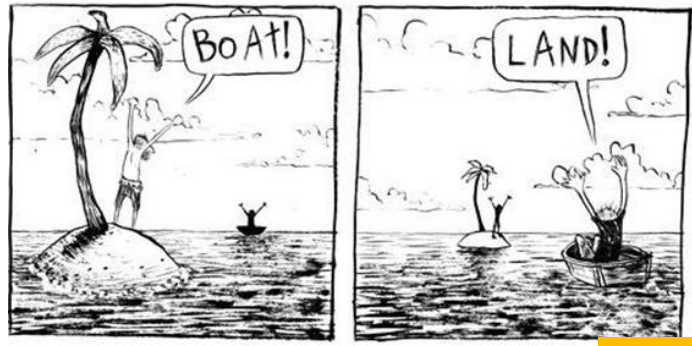
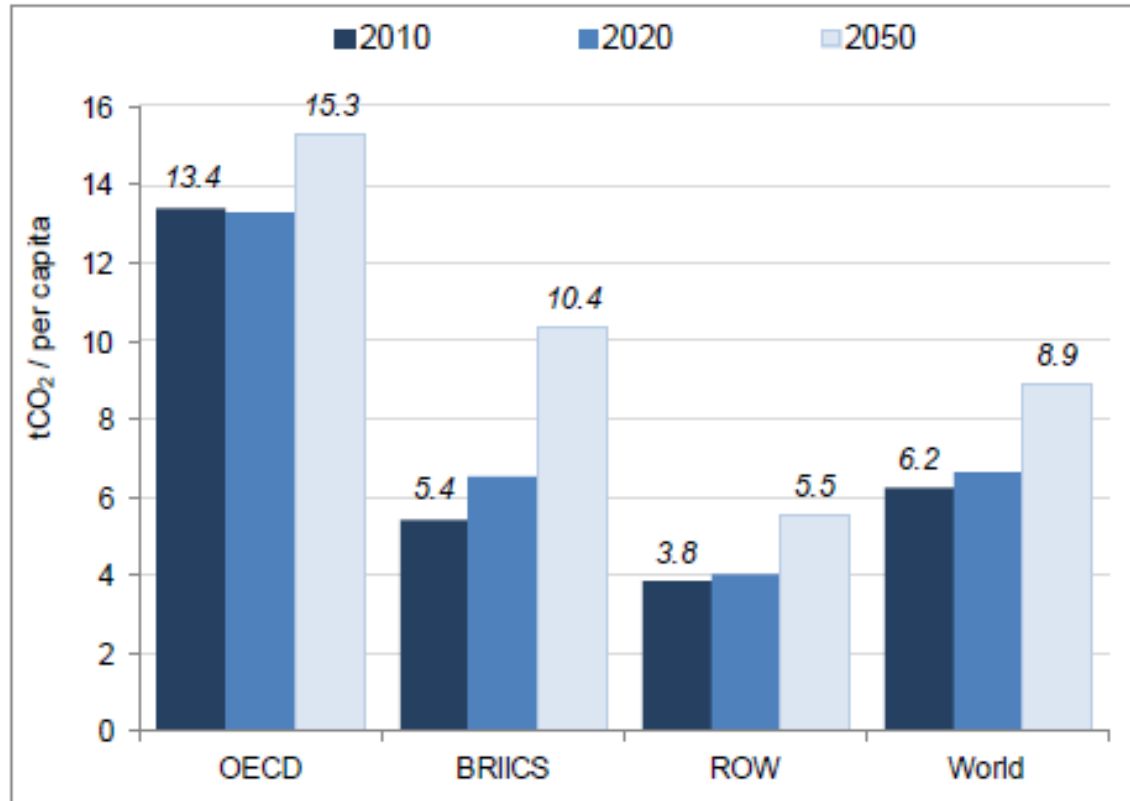


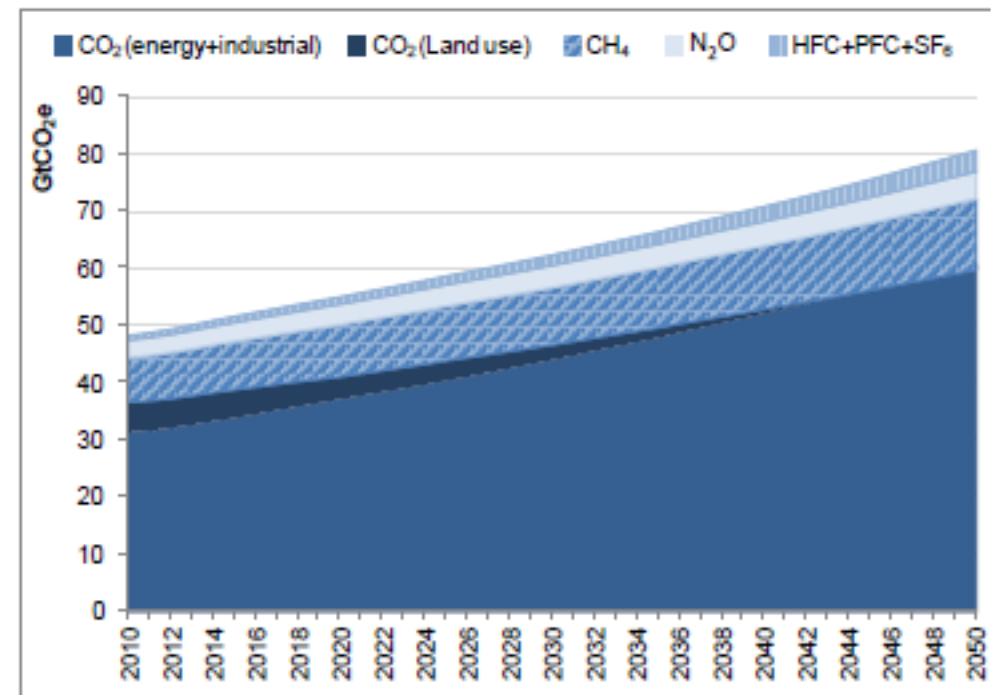


Figure 3.6. GHG emissions per capita: *Baseline, 2010-2050*



Source: OECD Environmental Outlook Baseline; output from IMAGE/ENV-Linkages.

a. By gases

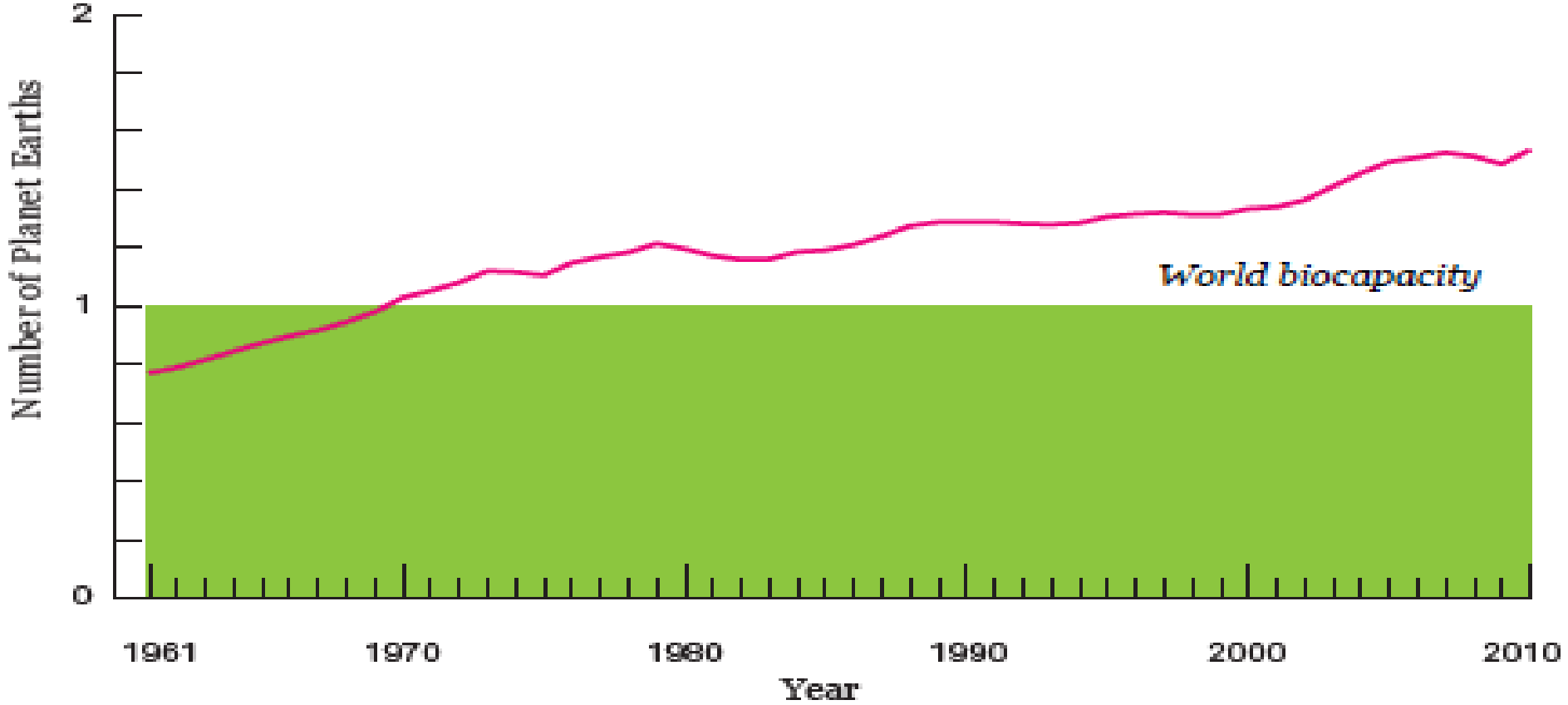


Source: OECD Environmental Outlook Baseline,

Source: OECD Environmental Outlook to 2050 (2011)



Global Ecological Footprint



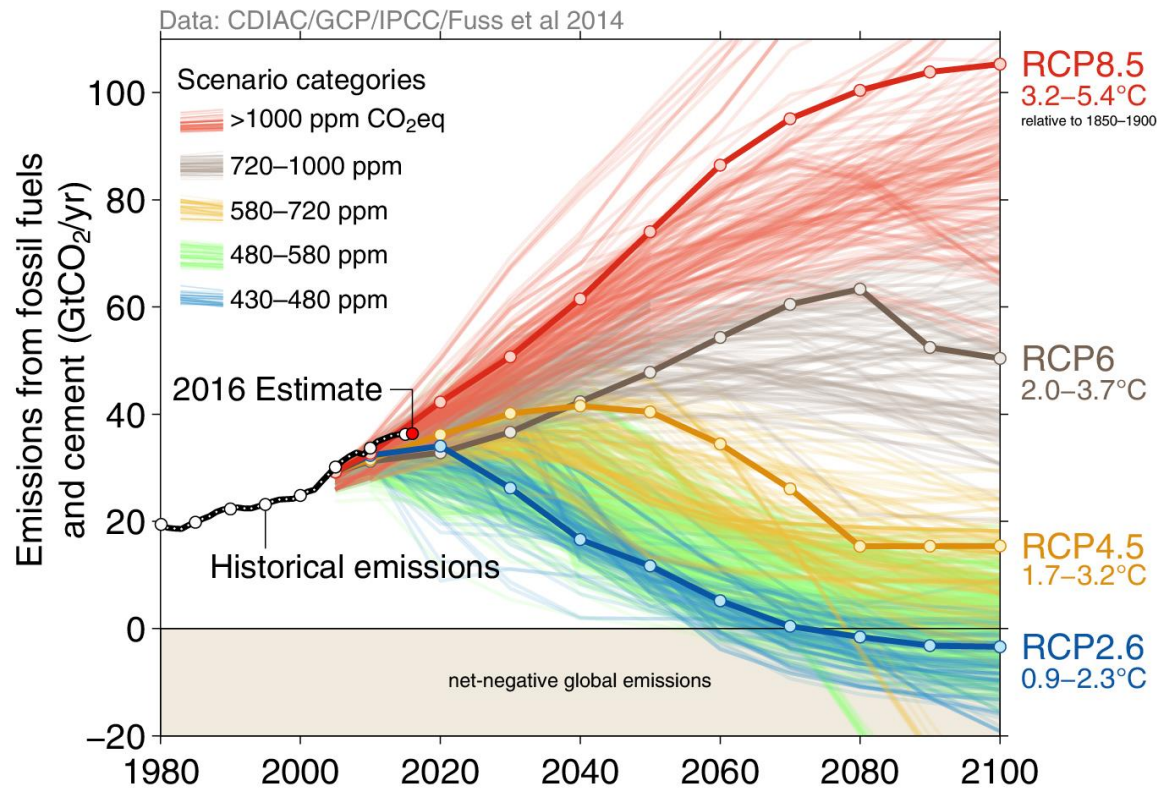
Source: WWF Living Planet Report 2014



Observed emissions and emissions scenarios



The emission pledges to the Paris Agreement avoid the worst effects of climate change (4-5°C)
 Most studies suggest the pledges give a likely temperature increase of about 3°C in 2100



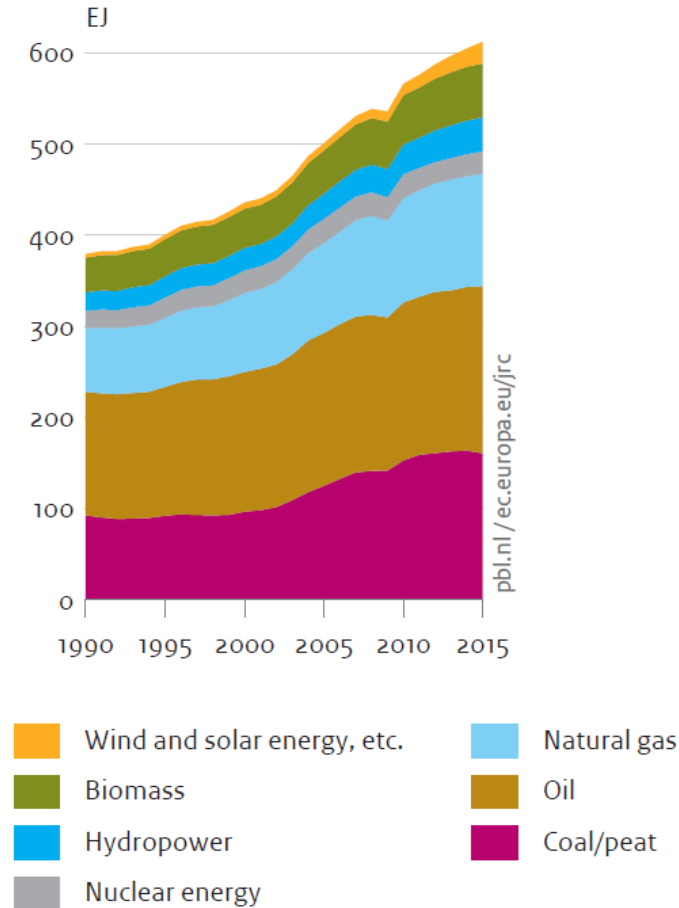
The IPCC Fifth Assessment Report assessed about 1 200 scenarios with detailed climate modelling on four Representative Concentration Pathways (RCPs)

Source: [Fuss et al 2014](#); [CDIAC](#); [IIASA AR5 Scenario Database](#); [Global Carbon Budget 2016](#)



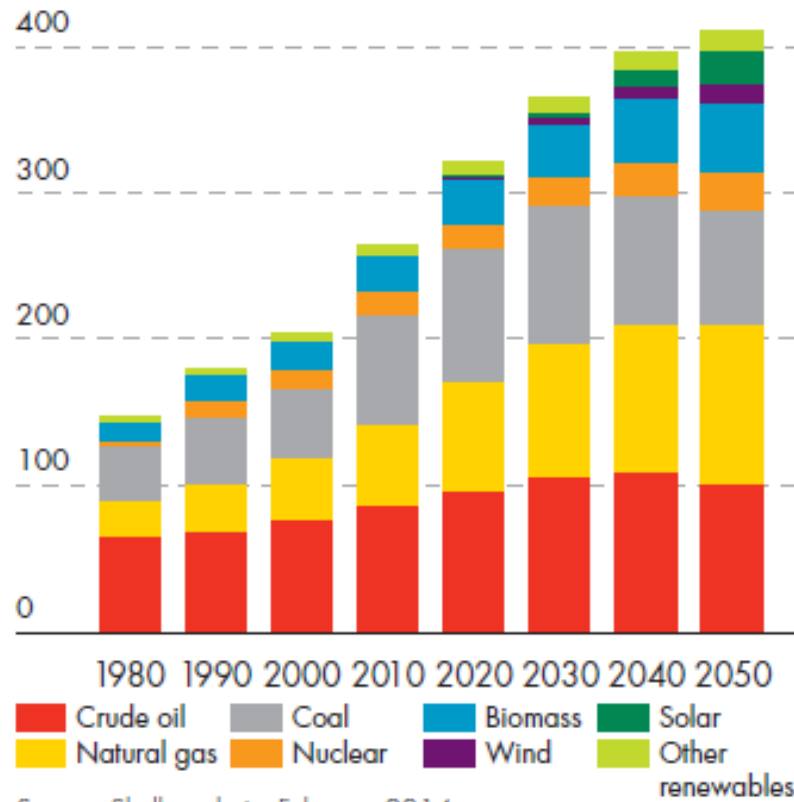
Total primary energy supply, per type

World



PROJECTED GLOBAL ENERGY DEMAND TO 2050

million barrels of oil equivalent a day



Source: Shell Sustainability Report 2014
*“Shell works to help meet **the world’s growing demand for energy** in a responsible way.”*



Chapter

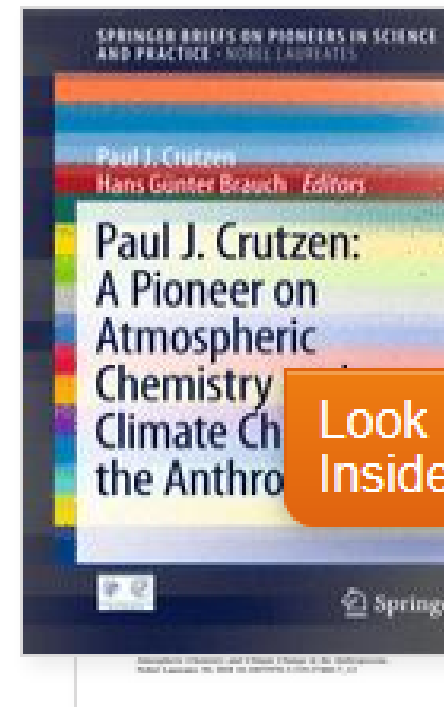
Paul J. Crutzen: A Pioneer on Atmospheric Chemistry and Climate Change in the Anthropocene

Volume 50 of the series SpringerBriefs on Pioneers in Science and Practice pp 227-238

Date: 16 April 2016

N_2O Release from Agro-biofuel Production Negates Global Warming Reduction by Replacing Fossil Fuels

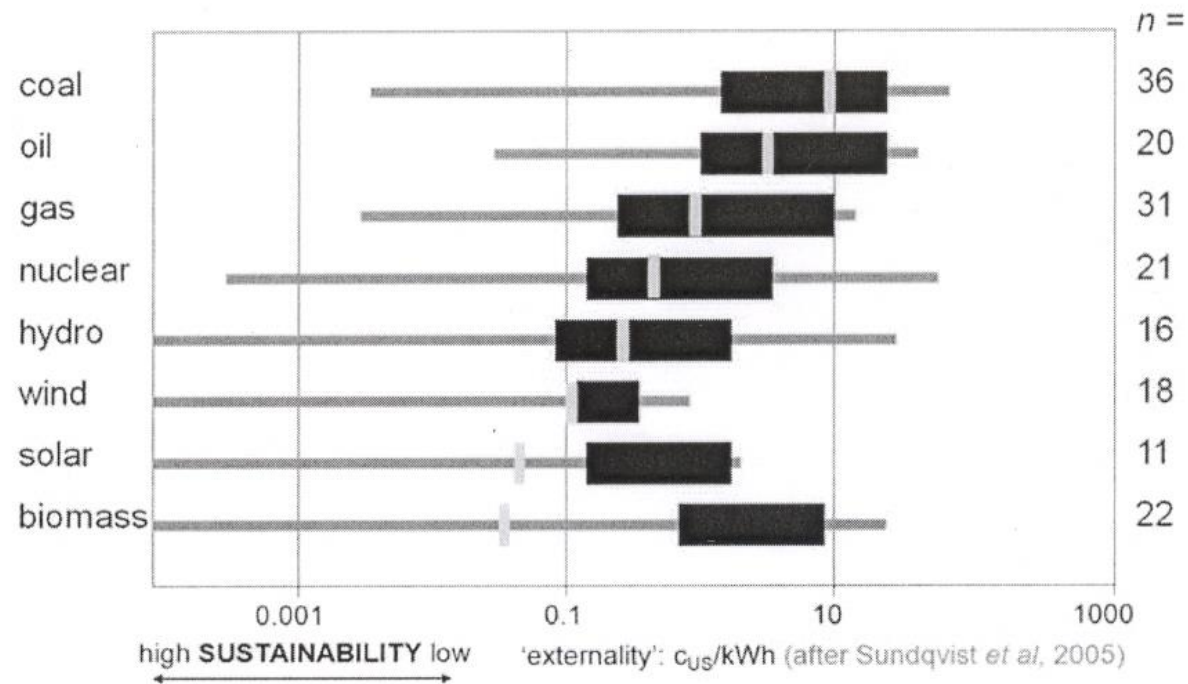
Paul J. Crutzen, A. R. Mosier, K. A. Smith, W. Winiwarter





The Limits to 'Sound Science'

Quantitative assessment appears precise, but is sensitive to 'framing'



Royal Academy of Engineering, Philosophy of Engineering, Vol. 2 (2011)
'Engineering, ethics and the environment', Andy Stirling



2. Competing Paradigmatic Conceptions of Reality..



Why is achieving Sustainability such a challenge?

Natural and Socio-technical Systems are inherently Complex.

Hence:

- **UNINTENDED CONSEQUENCES**/impossible to definitively predict with certainty;
- Deep **INTERCONNECTION** and **RECURSIVE** (pos/neg feedback) impacts
- Systems exhibit multiple levels of **REALITY**, experienced by **SUBJECTIVE AGENTS**

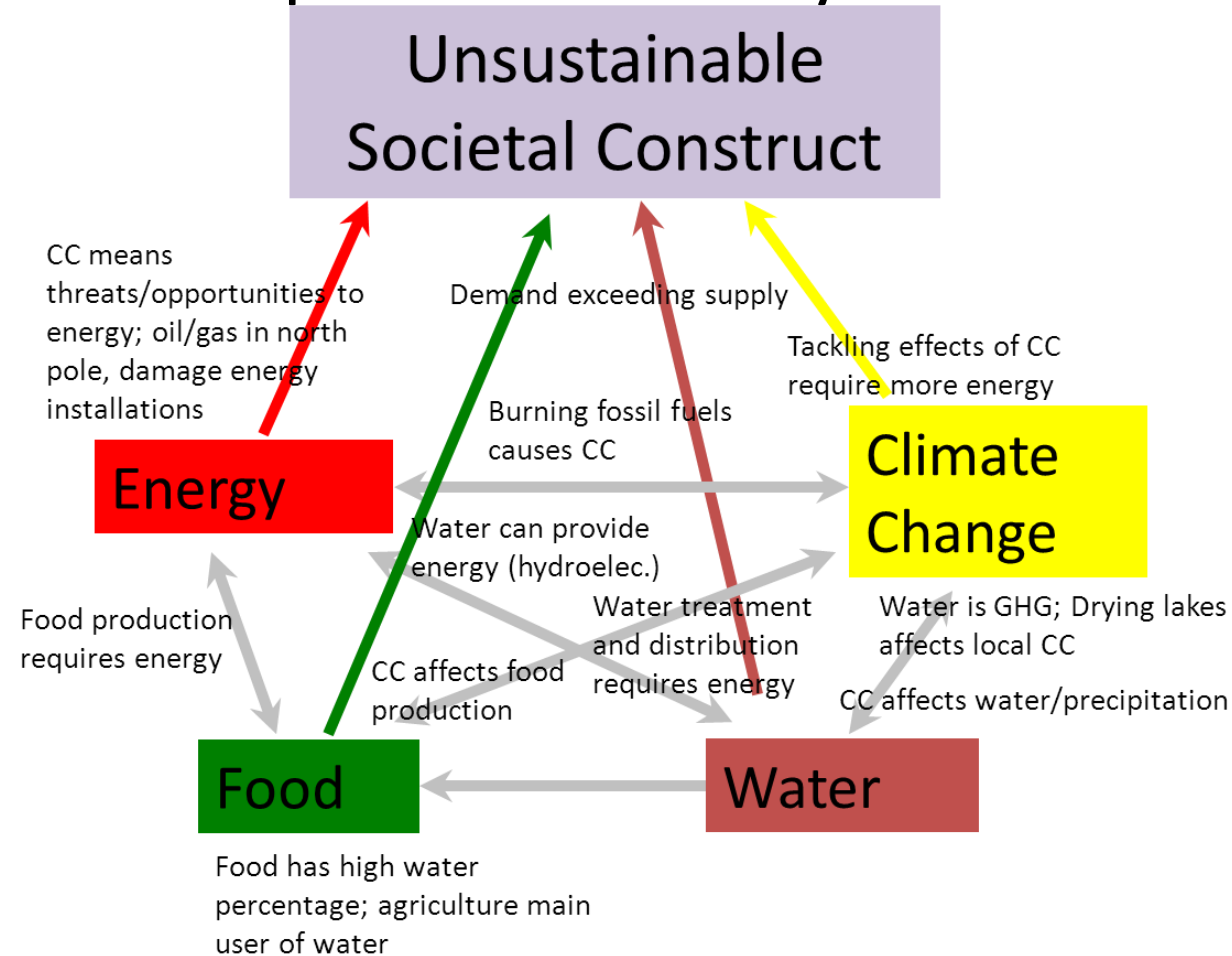
However, the Dominant Worldview/Paradigm conflicts with this Reality:

- **'PROGRESS'** is aligned with ongoing quantitative **CONSUMPTIVE GROWTH** (though physically impossible)
- Systems seen as causal/**DETERMINISTIC** driven by **SEPARATE COMPETING OBJECTIVE AGENTS**



An Unsustainable Global Construct

All these factors are linked via the **complex natural and social systems** we inhabit.





Interacting Influences; Interconnectivity

- **Columbian landslide** (1 April 2017; 300 deaths):
‘Global warming may have intensified the rain [but] ..deforestation in the surrounding mountains, driven by cattle ranchers and by farmers growing coca, the source of cocaine, degraded the environment and helped create the conditions that led to the disaster’ (p.6)

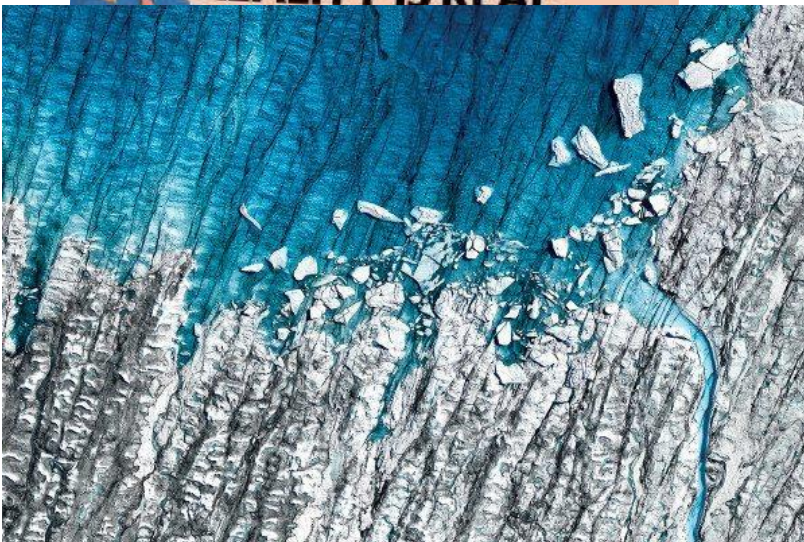


New Scientist, 8 April 2017



Complex unpredictability & Interconnectivity

- **Arctic Ice Sheet Melt:**



New Scientist, 8 April 2017

*‘[The] maximum March extent is at a record low, following a winter of heatwaves. ‘We are in a **new Arctic regime**’ ..‘We’re basically about 30 years ahead of where the models say we should be.’*

*..‘Climate models do include the loss of Arctic reflectivity ..but ..the change measured is **twice as large** as what **models predict**’ ..*

*‘we are losing a **vital mirror** that helped keep the planet cool. White snow and ice typically reflect 85 per cent of solar radiation back out into space, whereas dark ocean only reflects 10 per cent. ..The loss of sea ice has delivered a warming boost to the entire planet equivalent to **25 per cent** of the effect of rising CO₂ levels.’*

(pp.33-35)



Interconnectivity & Unintended Consequences



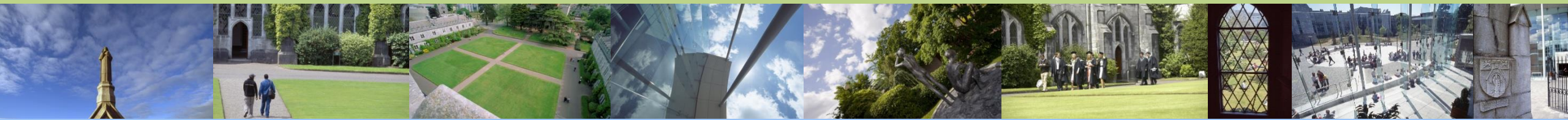
- **Antibiotic Overprescription:**

*‘There’s another problem with antibiotics: indiscriminately killing bugs is making us sick. ..Indiscriminately **wiping out bacteria** may be **contributing to rising levels of asthma, allergies, obesity and many more conditions***

*..Until the last decade, few imagined that gut bacteria might be needed for the development of our immune, metabolic and nervous systems. But it’s becoming clearer as links between the use of antibiotics and an **increased risk of diabetes, psychosis, anxiety, depression and obesity** steadily grow.*

(pp. 39-40)

New Scientist, 8 April 2017



Reflection:

How would we know when we've achieved
SUSTAINABILITY?

..Is it a quantitative or a qualitative property?



Ulrich Grober's Sustainability Test (2010)*:

- 1. Does it reduce the ecological footprint?***
- 2. Does it widen access to a good quality of life?***

**Die Entdeckung der Nachhaltigkeit – Kulturgeschichte eines Begriffs (2010)
(English translation: Sustainability A Cultural History (2012))*



John Ehrenfeld's Definition of Sustainability (2008):

“Sustainability is the possibility that humans and other life will flourish on Earth forever.”

Ehrenfeld (2013): ‘**Flourishing** is nothing more than a state recognized when one says: “All my **cares** are being **satisfied**, at least for the moment.”’



BARRIERS TO ACHIEVING SUSTAINABILITY?

**(APPROPRIATE ECOLOGICAL FOOTPRINT
+ GOOD LIFE/FLOURISHING)**

Paradigm of **SEPARATION**

...GROWTH

..& CONSUMPTION

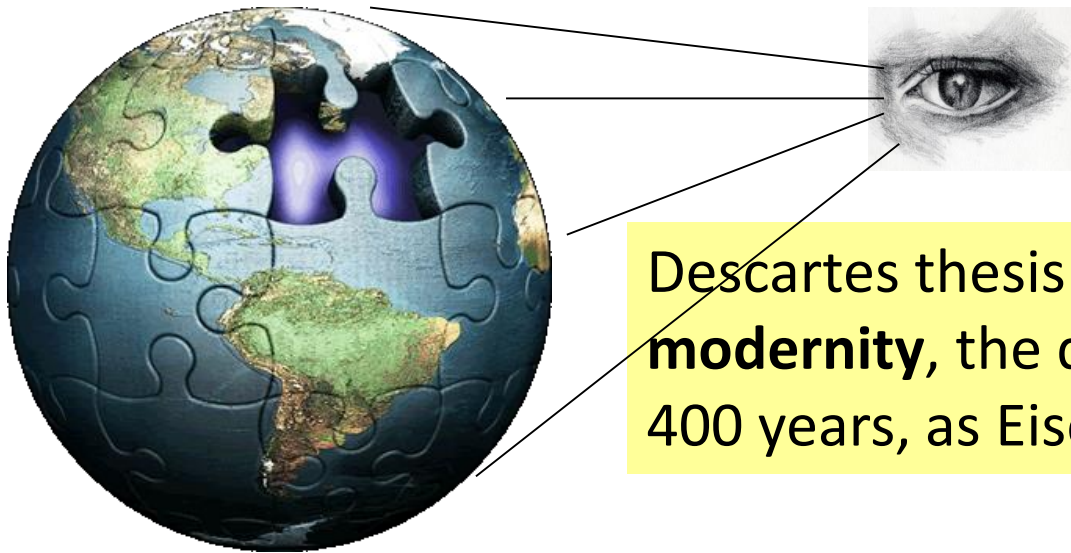


Paradigm of SEPARATION



Paradigm of SEPARATION

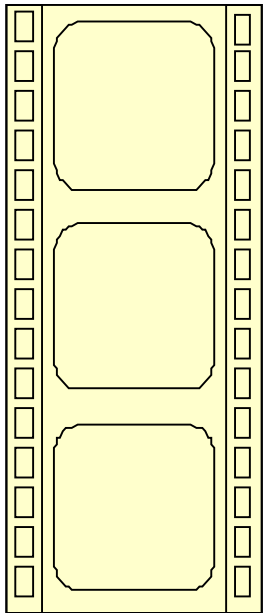
Through Rene **Descartes**' 'scientific' modernity, he sought **certainty** through **rationality**, based on an **antagonistic dualism** between the **objective** physical mechanical body & the entirely **separate subjective** mind/soul.



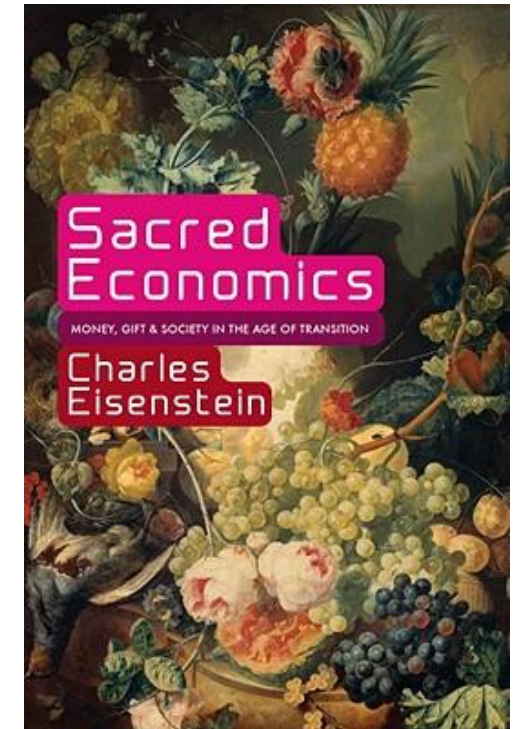
Descartes thesis was **hugely influential**, forming the basis for **modernity**, the dominant (reductionist) paradigm of the past 400 years, as Eisenstein (2012) calls 'the **Age of Separation**'.



Paradigm of SEPARATION



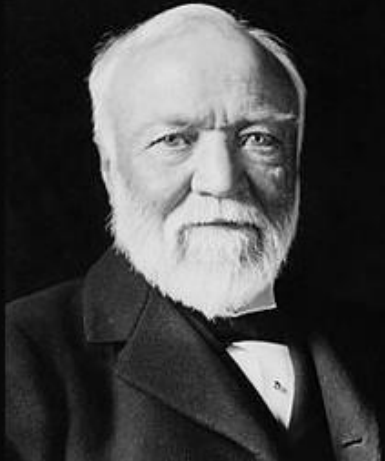
- Sacred Economics with **Charles Eisenstein** (2012)
<http://sacred-economics.com/> (0:37-2.00)





Paradigm of SEPARATION

Primacy of the Individual Agent/Object: 'Progress' through 'Survival of the fittest'



And while the law of competition may be sometimes hard for the individual, it is best for the race, because it ensures the survival of the fittest in every department.

(Andrew Carnegie)

izquotes.com

Carnegie (1835 – 1919) was a Scottish born American steel industry multi-millionaire and philanthropist.

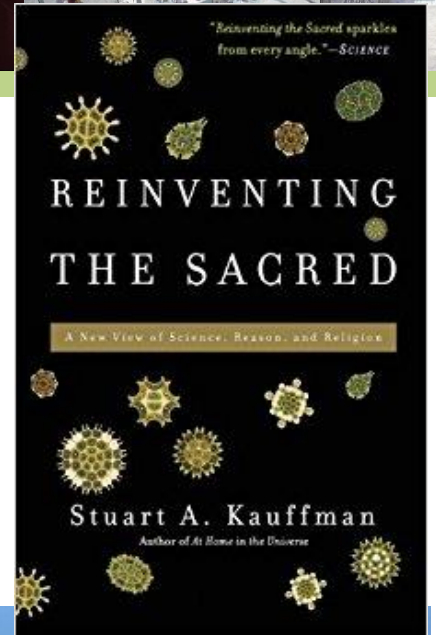
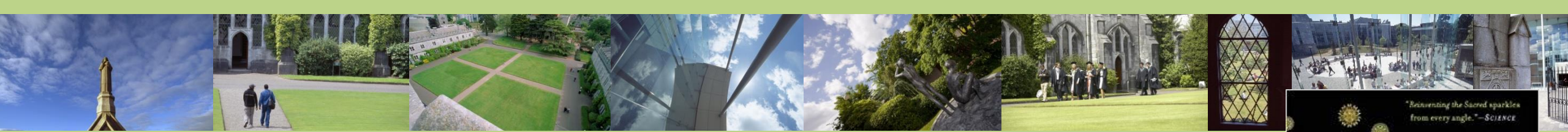


Paradigm of SEPARATION??

A Sudanese girl (March 1993): 'Vulture Stalking a Child' Kevin Carter, Pulitzer Prize for Feature Photography 1994



'I am haunted by the vivid memories of killings and corpses and anger and pain ... of starving or wounded children' ..suicide note, Kevin Carter (33), July 1994



Paradigm of SEPARATION??

Consider Earth and its Creatures as 'Sacred' (i.e. taboo to desecrate) (e.g. St. Francis' 'our Sister Mother Earth'), rather than some expendable economic 'Externality'.



Sacred Mount Athos, Greece

Cedars of Lebanon;
Bcherri Grove





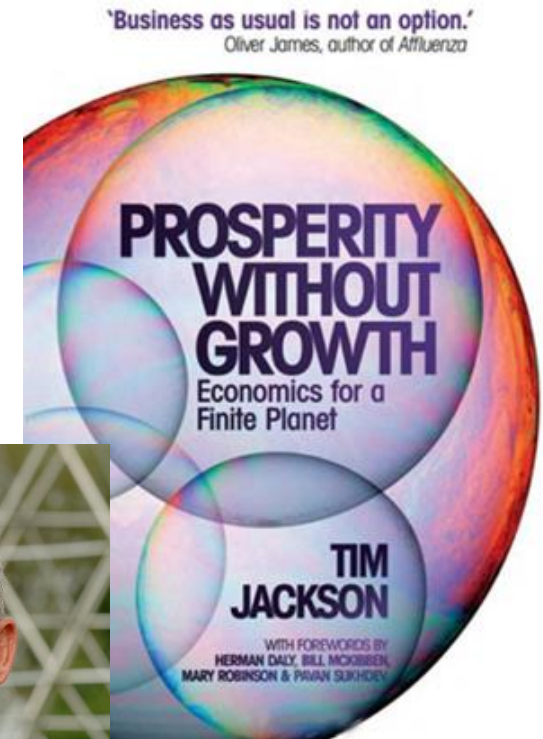
Paradigm of **GROWTH**



Paradigm of **GROWTH**

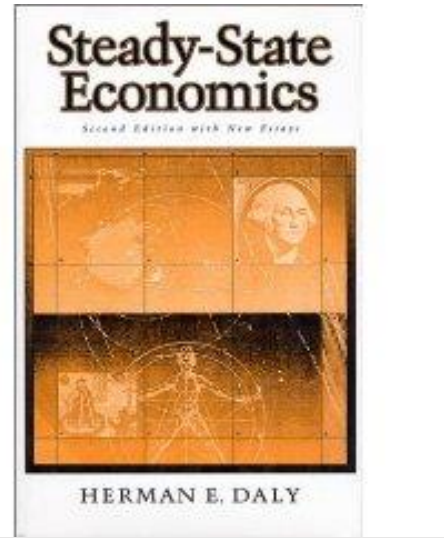
Tim Jackson (2009) argues in **‘Prosperity without Growth’** that we cannot find ‘prosperity’ in GDP growth:

*“An **economy** predicated on the perpetual expansion of debt-driven materialistic **consumption** is **unsustainable** ecologically, **problematic** socially and **unstable** economically”*





Paradigm of **GROWTH**



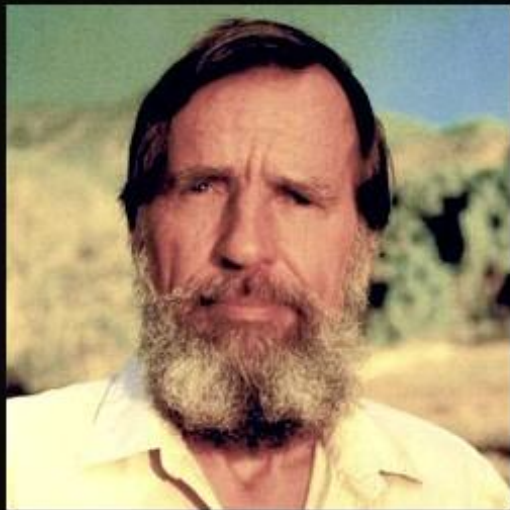
Herman Daly (2009):

*“When we **“grow up”** the first thing to do is to **stop further growth**, to become a **mature steady state** in physical dimensions, and then concentrate on **qualitative development** and maintenance: knowledge, wisdom, justice, ..etc.”*





Paradigm of GROWTH



Growth for the sake of growth is the ideology of the cancer cell.

(Edward Abbey)





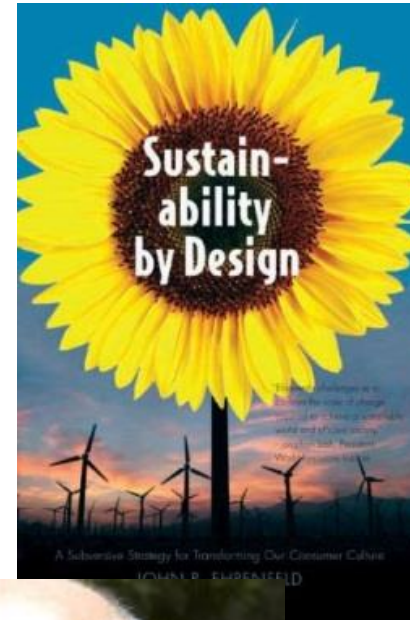
Paradigm of CONSUMPTION



Paradigm of CONSUMPTION

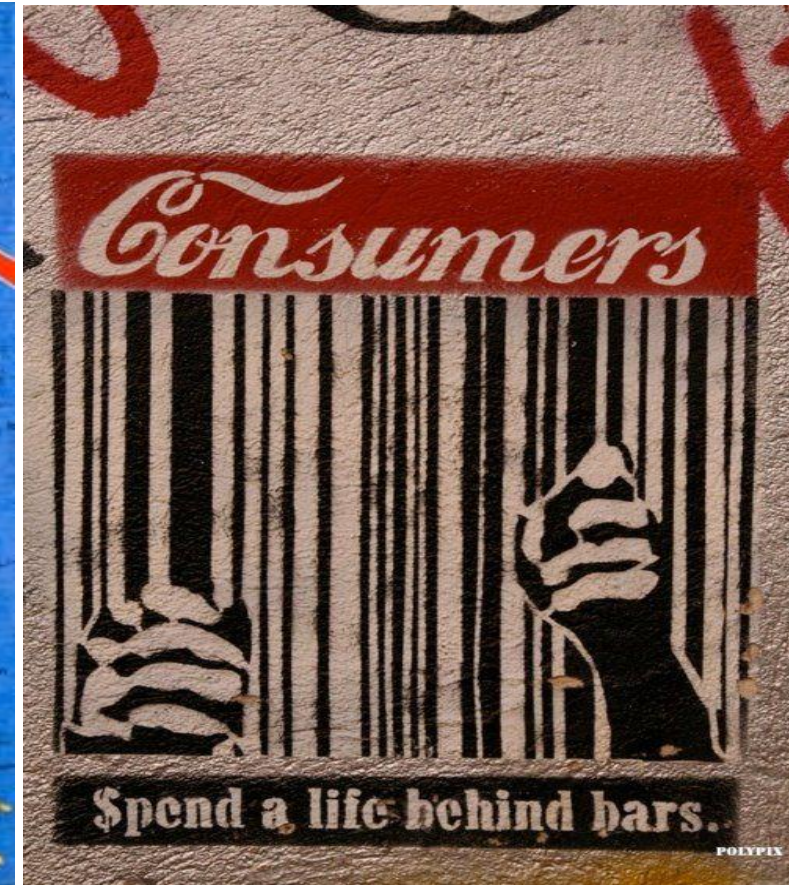
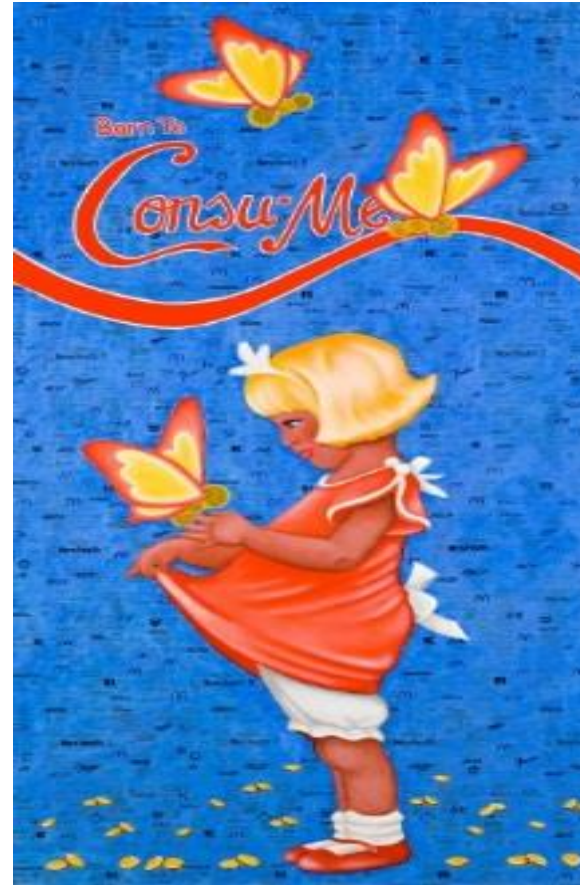
Ehrenfeld (2008):

Promoting **increased consumption** as a means of stimulating growth produces neither **prosperity** nor **flourishing** but rather **inauthenticity** leaving ‘a hole, something **unsatisfied** even if the task seems to have been successfully executed’, resulting in an **addictive** craving for more.





Paradigm of CONSUMPTION





Paradigm of CONSUMPTION





Paradigm of CONSUMPTION



patagonia
patagonia.com

How many brands can run an ad like this?

COMMON THREADS INITIATIVE

REDUCE

WE make useful gear that lasts a long time
YOU don't buy what you don't need

REPAIR

WE help you repair your Patagonia gear
YOU pledge to fix what's broken

REUSE

WE help find a home for Patagonia gear
you no longer need
YOU sell or pass it on*

RECYCLE

WE will take back your Patagonia gear
that is worn out
YOU pledge to keep your stuff out of
the landfill and incinerator



REIMAGINE

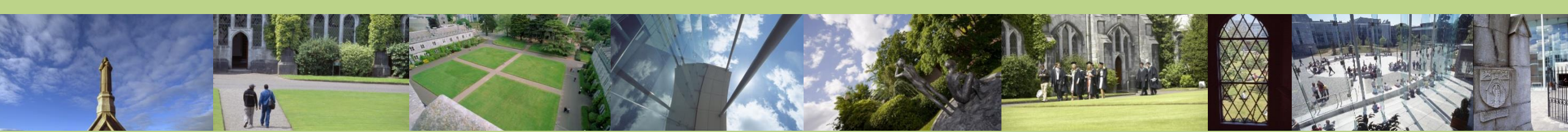
TOGETHER we reimagine a world where we take
only what nature can replace

patagonia



THIS YEAR, RISE ABOVE IT

BUY NOTHING DAY
BUY NOTHING CHRISTMAS
NOVEMBER 25TH/26TH

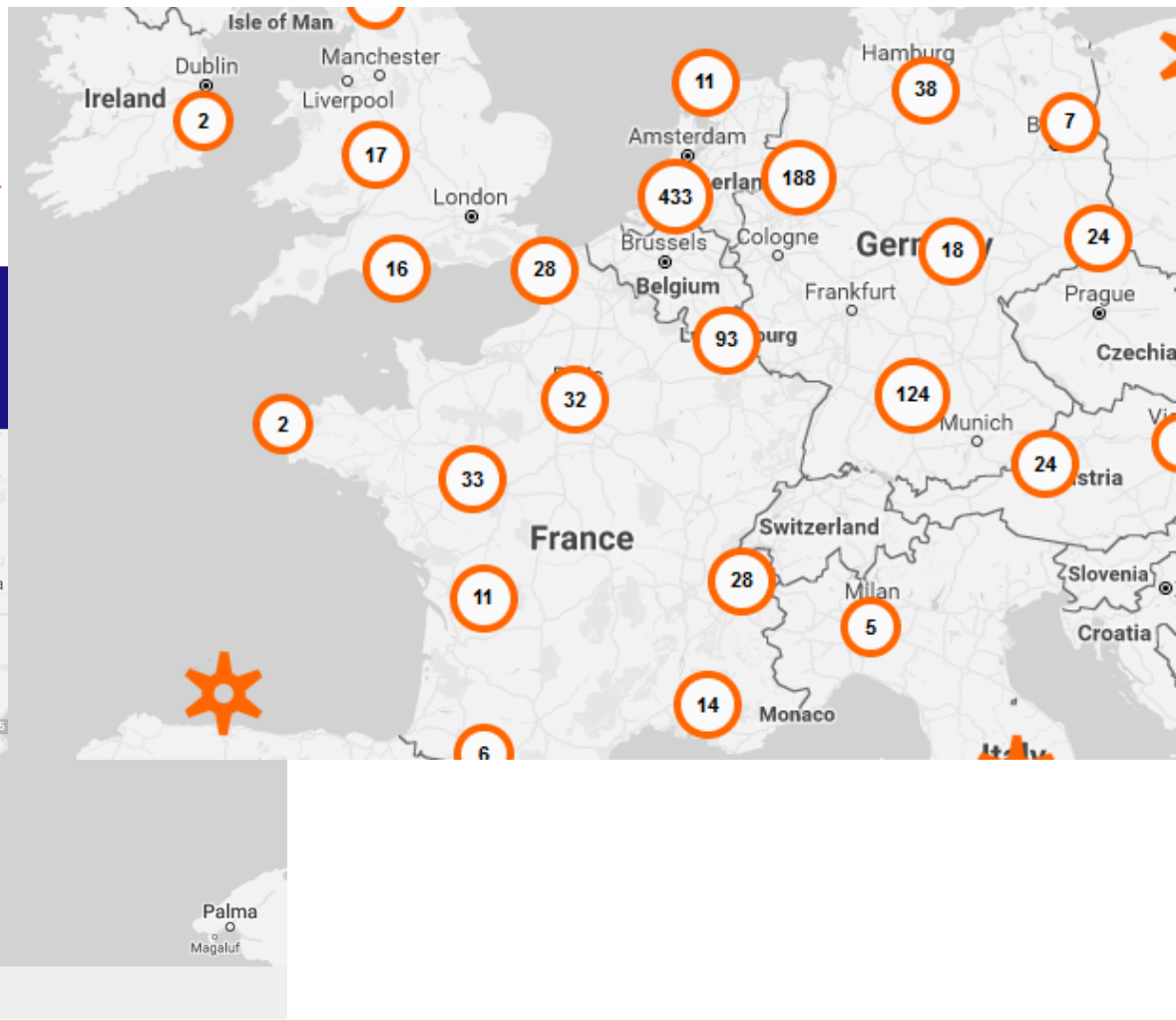


Paradigm of CONSUMPTION



HOME VISIT

Visit a Repair Café



VISIT ONE OF OUR 1251 REPAIR CAFÉS

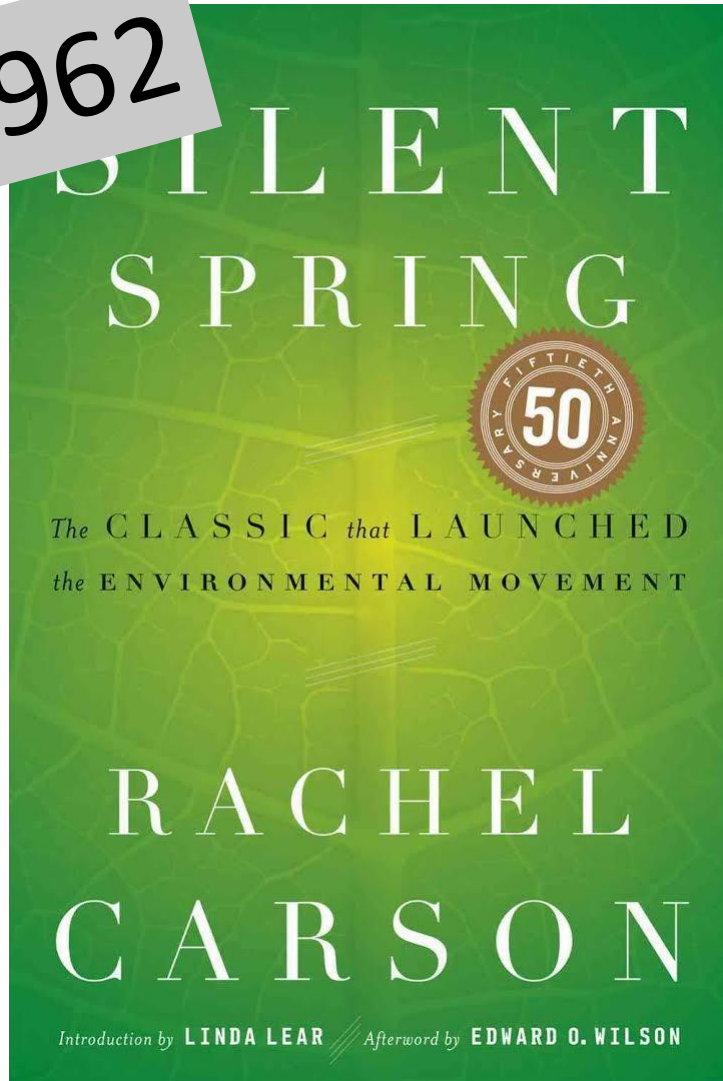
<https://repaircafe.org/en/visit/>



INTEGRATIVE Paradigm of **COMPLEXITY**
recognises inherent INTERCONNECTNESS,
inherent UNCERTAINTY,
requirement for TRANSDISCIPLINARITY



1962



*‘The history of life on earth has been a history or **interactions** between living things and their surroundings.’*

Rachel Carson,
Silent Spring

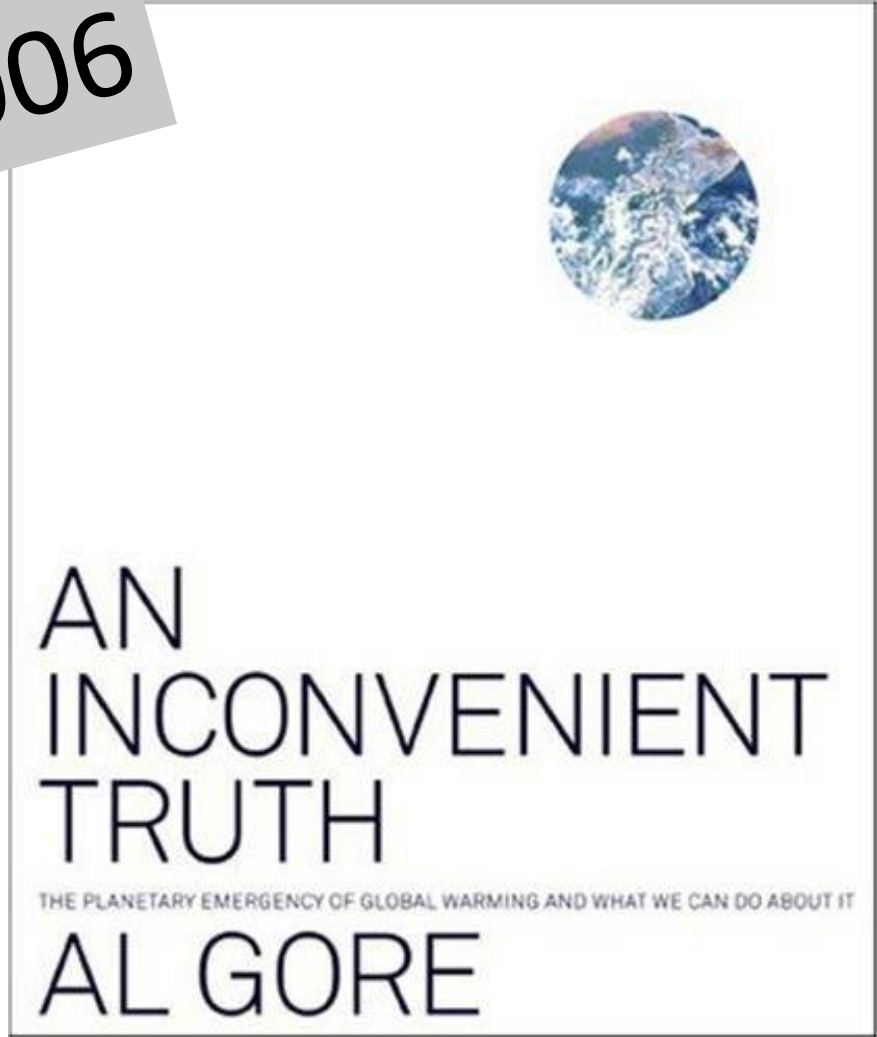


2006

*‘Our capacity for analysis sometimes leads us to an arrogant illusion: that we are so special and unique that nature isn’t **connected** to us.*

*But the fact is, we’re **inextricably tied**.’*

Al Gore,
An Inconvenient Truth





*‘It cannot be emphasized enough how **everything** is **interconnected**.*

*To seek **only** a **technical** remedy to each environmental problem which comes up is to **separate** what is in reality **interconnected** and to mask the true and deepest problems of the global system.*

*..[We can] limit and direct technology; we can put it at the service of **another type** of **progress**, one which is **healthier, more human, more social, more integral.**’*

2015

ON CARE FOR OUR
COMMON HOME
LAUDATO SI'





Modern

Associated with: Reductionist 'Science'; scientism

Self-contained 'value free' logic/rationality

Directed change (towards optimum: progress)

Technocratic techno-optimism

Seeks revealed certainty through reason

Progress through: Reductionist science

(Deconstructivist) Postmodern

Associated with: Deconstructivism

Scepticism

Constant decentred change (in space and time)

Ineliminable Uncertainty

Nihilism

Progress through: Pluralistic tolerance

Premodern (Traditional)

Associated with: Singular and comprehensive view of universe

Fixed hierarchical structure/order & Values

Irreducible mystery

Sacred

Progress through: Interpretations and Insights into the Unique, Divine Created Order

Integrative

Associated with: Recognition of: Irreducible Complexity,

Transdisciplinarity,

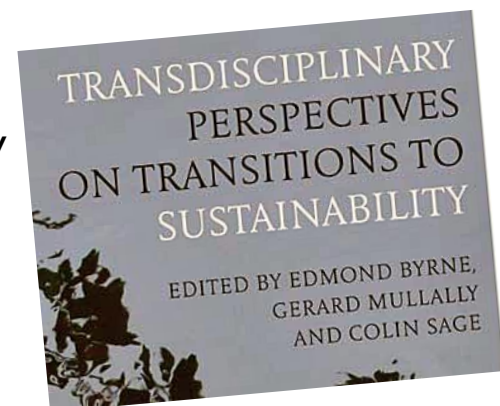
Normativity (/Values)

Interconnectedness, Recursivity and Reflexivity

Post-normal, Postformal

Progress through:

Integrative Science and Philosophy



Paradigmatic/Worldview Frameworks (Byrne, 2017, p.56), after Hedlund-de Witt & Hedlund-de Witt (2015)



“Several authors speak of the emergence of an **‘integral’** or **integrative worldview** in our contemporary cultural landscape, which is characterized by its tendency to bring together and **synthesize** perspectives that from the perspective of **other worldviews** tend to be considered mutually exclusive and polarized”
(Hedlund-de Witt, 2013)

For example as applied to the case of **organic** and **slow food** movements:

“individuals associated with these movements tend to be inspired by a pluriform value palette, which ...ranged from more **‘traditional’** values (such as an emphasis on and appreciation for family-owned farms; local livelihoods; traditional production methods; simple, seasonal, artisanal foods produced & prepared according to ‘grandmother recipes’; strong social ties between producer and consumer),
to **‘modern’** values (flourishing economies; pleasure of taste; high quality foods; abundance and variety; experimentation and innovation; health and nutrition),
to **‘postmodern’** values (environmental wellbeing; animal welfare; pure, natural foods and mindful eating; food choices as expression of one’s individuality; vitality and holistic health).”

(Hedlund-de Witt and Hedlund-de Witt, 2015)



Modern



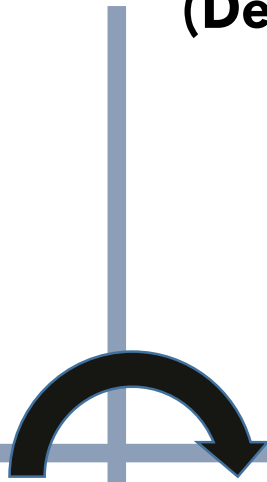
(Deconstructivist) Postmodern



Premodern (Traditional)



Integrative





3. Engineering Implications..



Are engineers 'value neutral'?

Should engineers be 'value neutral'?

Yes?

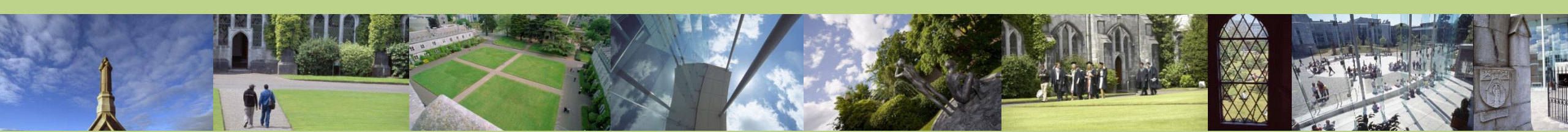


If so,
why so?

No?



If not,
what values should
engineering hold?



Engineering and Values



THE SOFTWARE ACTIVATES POLLUTION CONTROLS ONLY WHEN THE CAR IS BEING TESTED



“In engineering practice, value judgements are made all the time, often not explicitly – about the user, about robustness, about quality, about responsibilities, safety, societal benefit, risks and cost.” Bucciarelli (2008)



>1m kg plastic/hr enter world's oceans



Engineering and Values



Emphasis on:

- Increasing Supply over Reducing Demand
- Short term horizon

But not on: - "Unintended" consequences

able Environments.



Photograph by M...
iversity of Sarawak's rolling lowlands in favor of a sin...
some eight million acres of Borneo—an area roug...

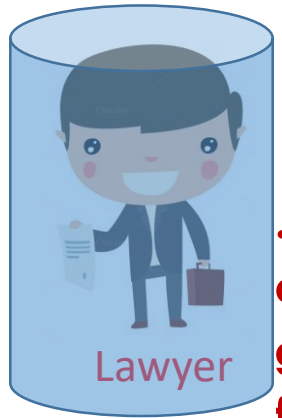


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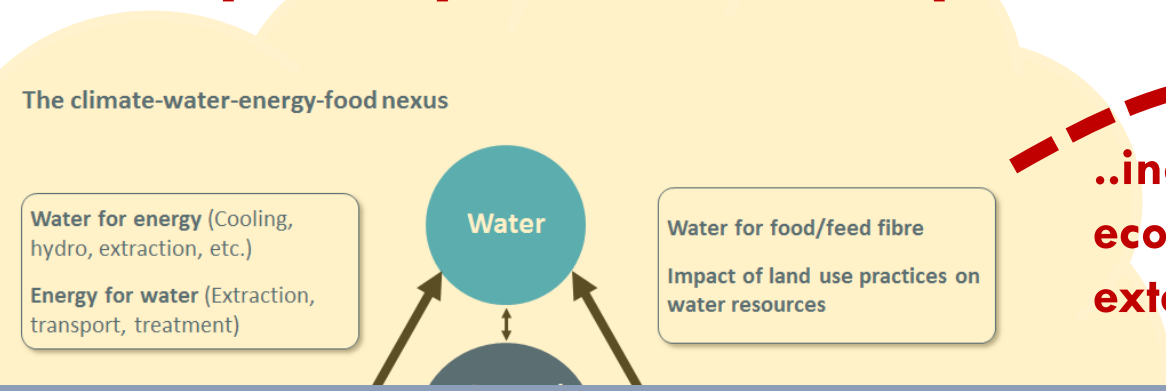
>1m kg plastic/hr enter world's oceans



A Problem of... ..disciplinary silo-ised 'object world' views

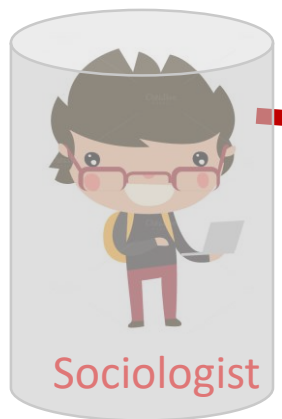


**..developing/
applying a
global legal
frame**



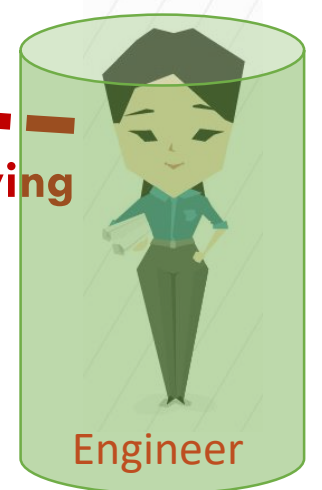
**..incorporating
economic
externalities**

'There are no whole truths; all truths are half-truths. It is trying to treat them as whole truths that plays the devil.'
Alfred North Whitehead (1954)



..how humans relate to world around them through stories, myths, (meta-)narratives; ultimately an issue of ethics

**..developing/ applying
appropriate
technologies**





Transdisciplinarity; seeking *emergent* knowledge

built on strong *disciplinary* pillars,
while *transcending* them



Los Cuatro Postes, Ávila, Spain

‘Unitas multiplex’ (Morin, 2008)

‘Unity amidst diversity and diversity through the unity’ (Klein, 2004)

Morin, E., 2008. On Complexity. Hampton Press.
Klein, J. T., 2004. Prospects for transdisciplinarity. *Futures*, 36, 515-526.



Normal Science and Mutual Misunderstandings

Engineers and scientists traditionally tend to presume that if the **public** had **more** technical **knowledge** then they would come around to **accepting** various **projects** that arouse public **opposition**.

However, this is generally erroneous – the public is more concerned with issues of:

- **Ethics/values**
- **Policies**
- **Risk**
- **Safety**

*don't frack
with Leitrim* 



These are **normative** and **value laden** issues, often displaying **high uncertainty**; thus science or engineering are **incapable of giving 'objective', absolute or definitive answers**.

This leads to **misunderstandings** (/parties talking over each other), often leading to mutual **misconceptions** and **distrust**, including public distrust in rational expert science/technology.

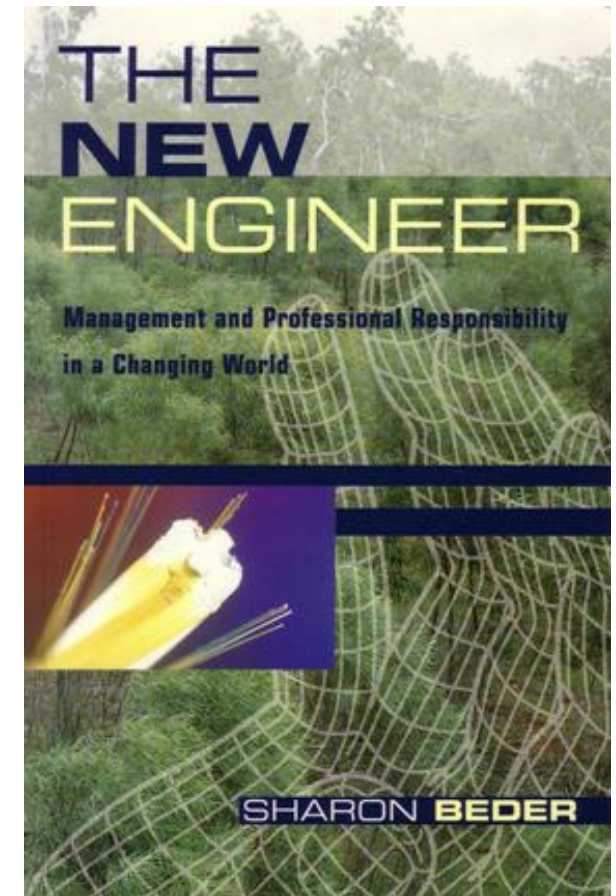


The New Engineer

*“A broader, more general approach is required ...there is also a need [for] an understanding of the **social context** within which [young engineers] will work, together with skills in **critical analysis** and **ethical judgement**, and an ability to **assess long-term consequences** of their work.*

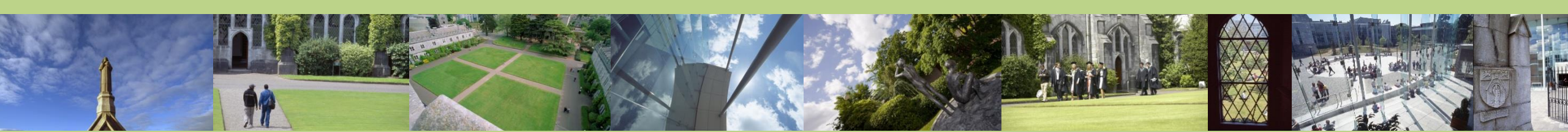
*In this way the new graduates can **transform** the profession and take their place as the **new engineers for the 21st century**”*

Sharon Beder, 1998



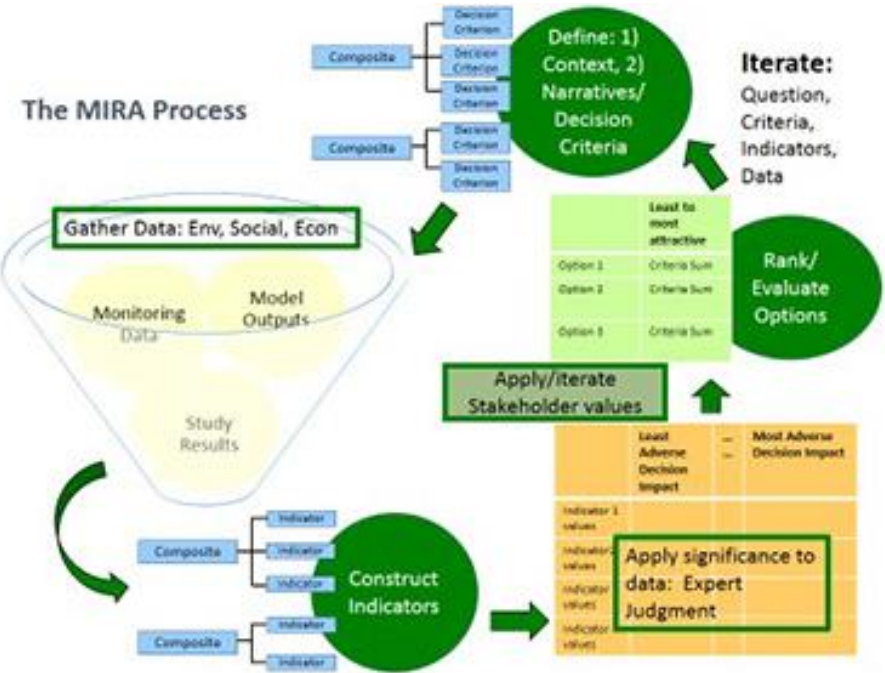


4. (New) Engineering Approaches..

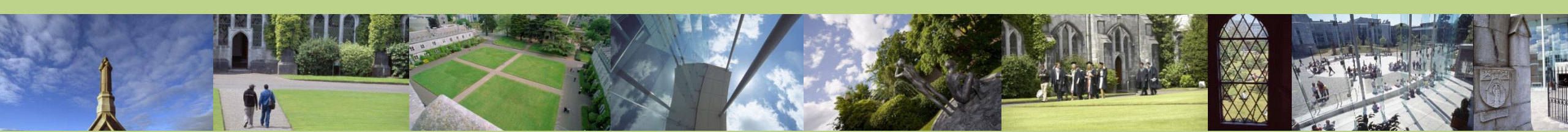


A New (Engineer) Approach?

“To address “wicked problems” the USEPA3 has developed the [Multi-criteria Integrated Resource Assessment](#) (MIRA) decision analytic approach that **engages stakeholder participation through transparency, trans-disciplinary learning, and the explicit use of value sets.**

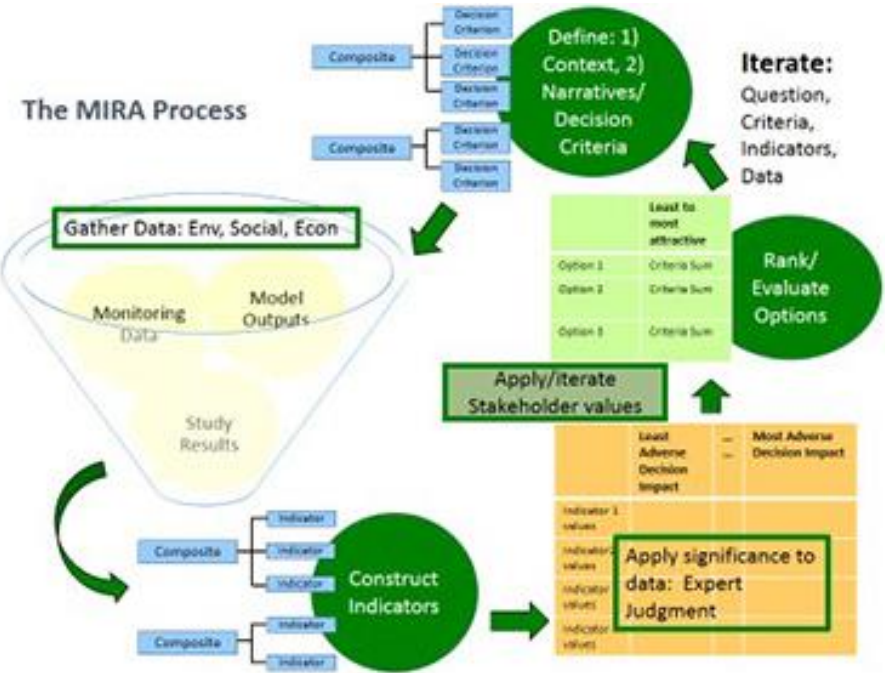


*This is a more **inclusive problem solving process** than **optimal, least-cost decision analysis** or **expert-stakeholder models** which tend to blur the important differences between expert judgements and stakeholder values.”*



A New (Engineer) Approach?

“To address “wicked problems” the USEPA3 has developed the [Multi-criteria Integrated Resource Assessment](#) (MIRA) decision analytic approach that **engages stakeholder participation through transparency, trans-disciplinary learning, and the explicit use of value sets.**



“The **ostensibly cheaper technical option** at the start may prove to be very costly in the medium to longer term if the project is prevented from getting underway, while early, time consuming but effective participative mechanisms may allow a more direct implementation route, thus saving time and money.”



Some Other Approaches..



BIOMIMICRY

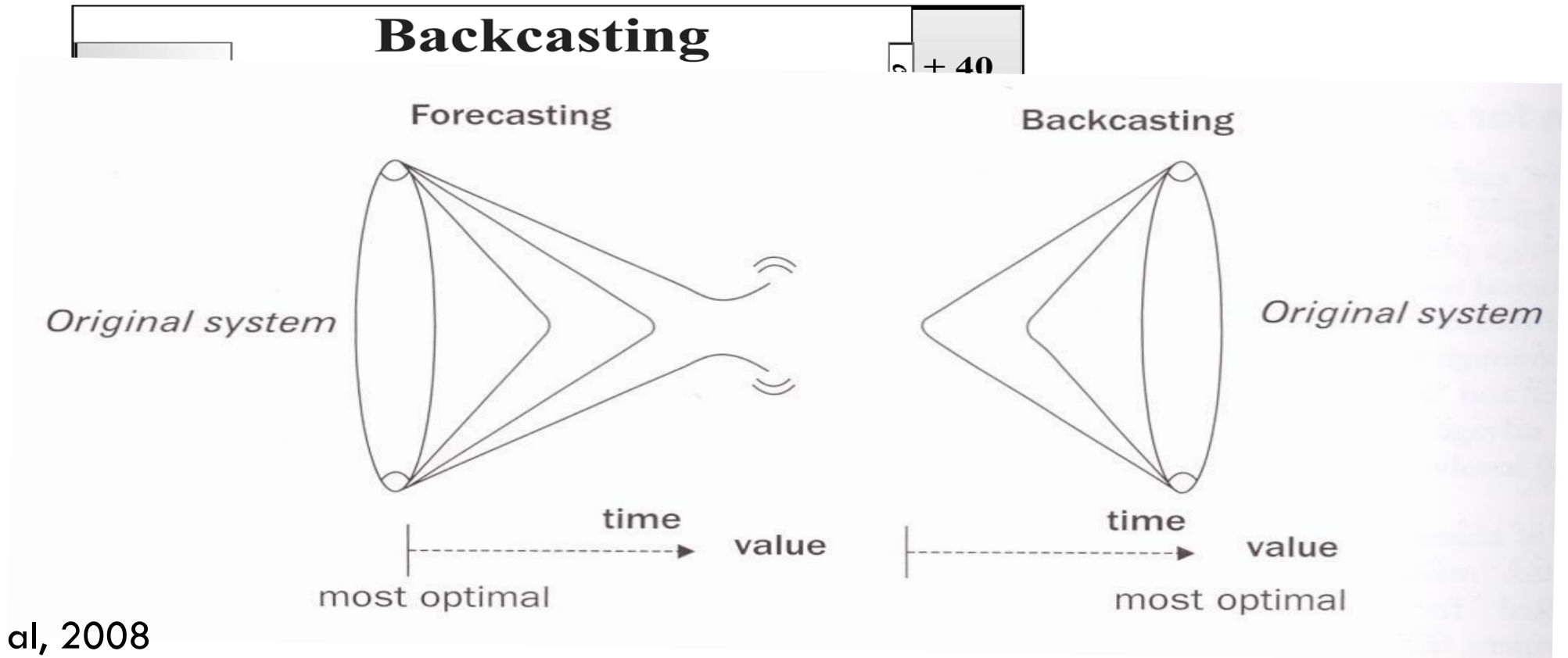
Nature provides a myriad of **innovative solutions** to problems, many of which have the potential to inform and **inspire human design**. (including circular economy inspired no waste processes). e.g. Interface and its carpet tiles



These solutions are honed over evolutionary timeframes and do not involve toxic waste or nasty side effects.



BACKCASTING



Stasinopoulos et al, 2008
(Adapted from Lovins, 2002)



FORECASTING:



Toyota Prius 2nd Gen
(2004-9)



3rd Gen
(ex 2010)



Plug in Hybrid
(ex 2011)

	2 nd Gen	3 rd Gen	
CO ₂ (g/km)	104	89	<i>Improved Efficiency</i>
Fuel Efficiency (comb., l/km)	5.0	3.9	
Mass Battery	45	44	<i>More material and energy: 'Rebound'</i>
Length/Width (m)	4.45/1.725	4.46/1.745	
Kerb weight (kg)	1317	1379	
Power (kW)	82	100	



BACKCASTING

Mass produced small Electric Vehicles available for public use

(e.g. Autolib cars in Paris to complement Velib bicycle scheme)

Also: Paris, Madrid, Athens,

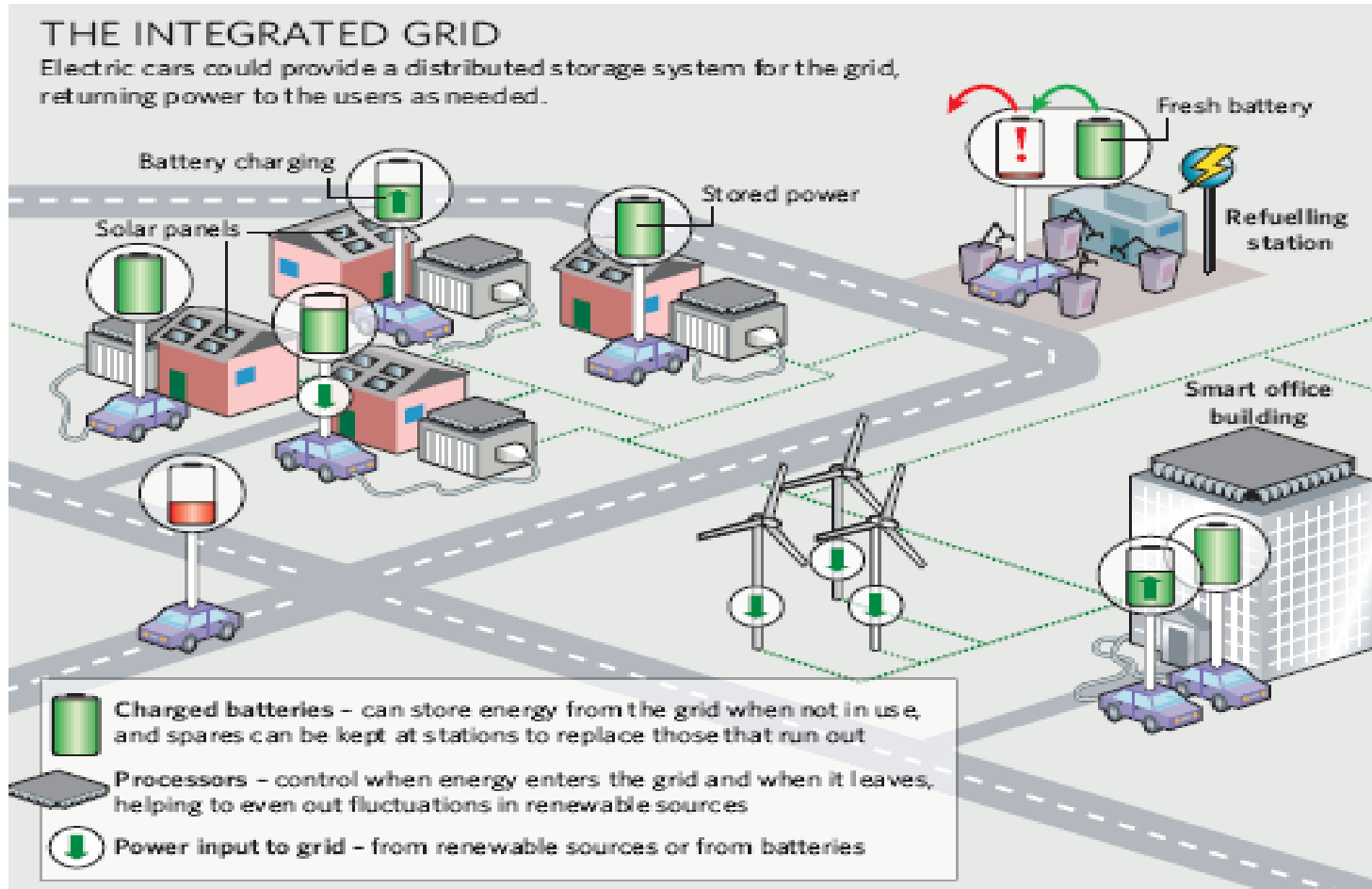
Mexico City banning

diesel vehicles by 2025





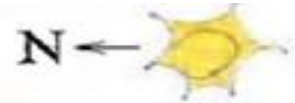
BACKCASTING; INTEGRATED SUSTAINABLE LIVING



Tolletson (2008), *Nature*, 456, 436-440

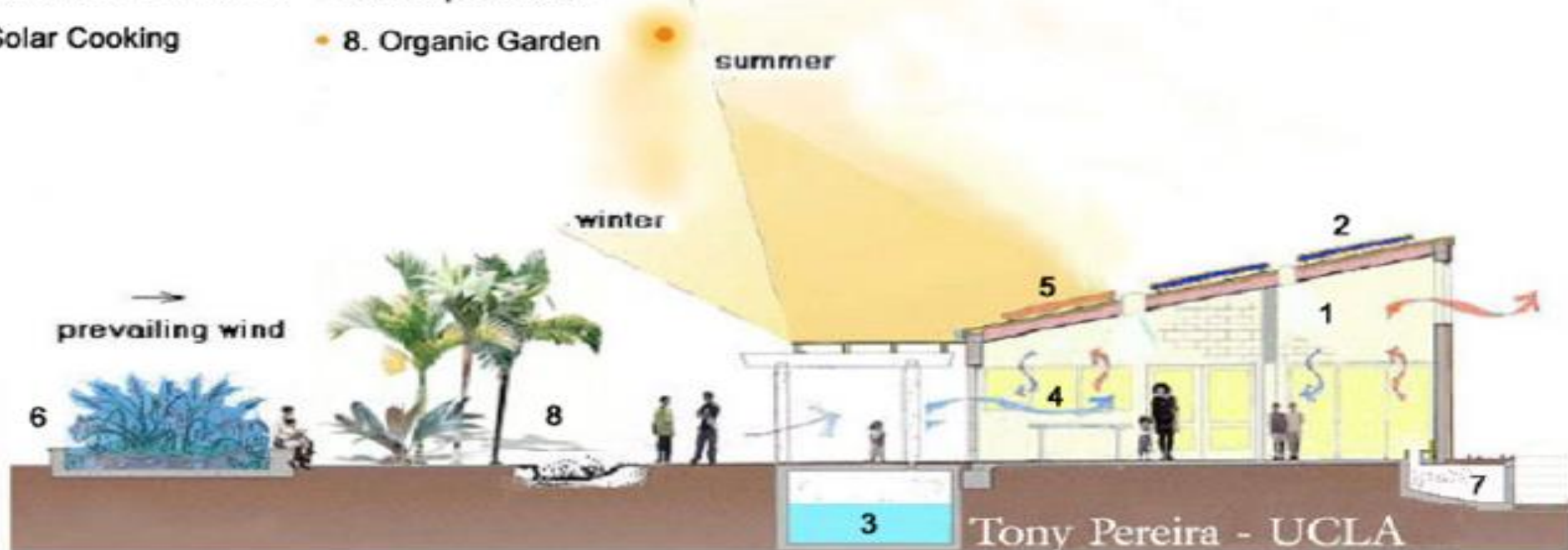


BACKCASTING; INTEGRATED SUSTAINABLE LIVING



Integral Sustainable Design

- 1. Passive Solar Home
- 2. Solar Photovoltaic
- 3. Rainwater Catchment
- 4. Solar Cooking
- 5. Solar Domestic Hot Water
- 6. Greywater Mini-Marsh
- 7. Compost Toilet
- 8. Organic Garden



Pereira (2009) *Renew Sus Energy Rev*, 13, 1133-1137.



DESIGN FOR BEHAVIOURAL CHANGE

**‘Sustainability by Design – A subversive strategy for transforming our consumer culture.’
John Ehrenfeld (2008)**



Design decisions which have implications for **values, habits** and **culture** are being made all the time by design engineers; who can **force consumers** to **explicitly examine** their **value hierarchies**, and hence create **new patterns of behaviour**.



5. Case Study – Building in the Human Element..



Case Study:

6 Star Green Building: School of Sustainable Development, Bond University, Australia



Best, R. (2015). Teaching sustainability in a six star green building. *7th Engineering Education for Sustainable Development Conference*. 9-12 June, 2015. Vancouver, Canada: University of British Columbia.



6 Star Green Building: School of Sustainable Development, Bond University

‘While the building’s occupants are generally happy with it as a place to work and study, the SSD building would be unlikely to achieve any Green Star rating in its current condition.



By the end of 2013 the following building components were compromised or missing:

- The **building management system (BMS)** had **largely ceased putting the building into natural ventilation mode** - it was originally programmed to **disable the air conditioning** and open upper level windows in corridors when outside conditions of temperature and humidity meant that the building could **run just on fresh air**. Due to some **failed sensors** and an **incremental narrowing of the comfort band** (due to differing requests from occupants) the BMS was no longer doing its job.’



6 Star Green Building: School of Sustainable Development, Bond University

‘Some aspects of the building have always caused some difficulties for staff and students, notably the problems encountered when the **data projectors** are used in the teaching spaces.

As the **lights** are controlled by **motion and light level sensors** it has generally been difficult to keep light levels so that the detail of the projected material is easily read while maintaining enough light for people to take notes. Until very recently there were **no light switches** in the studios (part of the green design) and when the **incoming natural light** was **bright** enough to make it hard to read the screens, the only alternative was to **close the blinds**. This **darkened the room** somewhat but that caused the BMS to **increase** the level of the **artificial lighting** and the problem remained. Several years ago a request for lighting controls was lodged, however, initial approval was reversed because there was a fear (unfounded) that installing switches would compromise the building’s Green Star rating.’





6 Star Green Building: School of Sustainable Development, Bond University

‘Healy (2011), a services engineer involved in the early stages of the SSD design, believes that the building is **‘over-engineered’** inasmuch as the successful operation of the building relies **too heavily on a large number of**

sensors and switches that inform the BMS and allow the building to function as intended.

Not only does the failure of any of these components compromise the functionality of the building but **monitoring** and **replacing** these items is quite **expensive** due to both the cost of the labour involved and the high cost of purchasing replacements.

The dangers of the sort of ‘over-engineering’ that Healy was concerned about were identified more than 20 years ago by Vaughan and Jones (1994) who wrote:

*‘There is often a pre-occupation with intricate or exotic solutions or devices which actually have less impact on building performance than **fundamentals** such as **building orientation.**’*





6 Star Green Building: School of Sustainable Development, Bond University

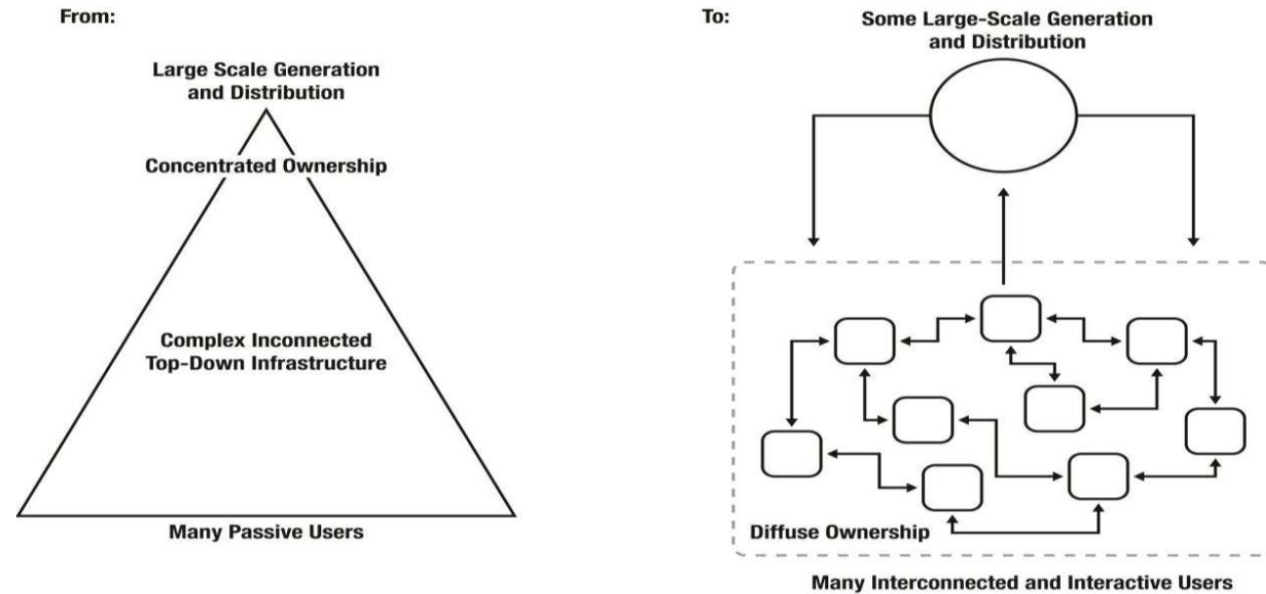


‘Some of the best features of the building are the **abundance of natural light** in most spaces and the way the building, particularly on the top floor, **catches every available breeze**, which is a key comfort factor in a building located in a sub-tropical climate with warm, humid summers. These are **passive features** that produce ongoing benefits for occupants and the building’s owner yet they require no ‘exotic solutions or devices’ and, indeed, **correct orientation** of the building is one of the key factors.’



Localism and energy: Negotiating approaches to embedding resilience in energy systems.

O'Brien, G., Hope, A., (2010).
Energy Policy, 38, 7550-7558.



*‘This concentration on **remote centralised sources of energy**, renewable or not, also removes the end user from the energy generating process, which acts to **lower understanding** of the energy system, and the importance of **reducing demand**.’*



...now its over to you!*

*Be Creative!! 😊