FROM ANTHROPOCENE TO SUSTAINOCENE

Challenges and opportunities

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Paul Crutzen (2000)
Naming the anthropocene

Fig 1
James Watt’s steam engine (1754)
Stephenson’s Rocket (1829)
60 kph

Fig 3
World Rail Speed Record (France 2007)
Svante Arrhenius (1896)
Greenhouse gases
Greenhouse Gas Emissions

Fig 6
## CARBON COSTS OF ENERGY

<table>
<thead>
<tr>
<th>Power Source</th>
<th>CO&lt;sub&gt;2&lt;/sub&gt; in g/kWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nuclear</td>
<td>4</td>
</tr>
<tr>
<td>Wind</td>
<td>8</td>
</tr>
<tr>
<td>Large scale hydro</td>
<td>8</td>
</tr>
<tr>
<td>Energy crops</td>
<td>17</td>
</tr>
<tr>
<td>Geothermal</td>
<td>79</td>
</tr>
<tr>
<td>Solar</td>
<td>133</td>
</tr>
<tr>
<td>Gas</td>
<td>430*</td>
</tr>
<tr>
<td>Diesel</td>
<td>772</td>
</tr>
<tr>
<td>Oil</td>
<td>828</td>
</tr>
<tr>
<td>Coal</td>
<td>955**</td>
</tr>
</tbody>
</table>

(UK Govt’s Energy Technology Support Unit Report, 2008)
Mean global land-ocean temperature anomalies (°C)

Hansen et al., 2006. Annotated by AYG

Fig 8
Fig 9

Arctic sea ice loss compared to IPCC models

% CHANGE FROM 1979–1990 MEAN

- Satellite (1979-2007)
- Mean IPCC
- Most likely development
- IPCC range

Year

1960 1980 2000 2020 2040 2060 2080
Human Population Growth

Fig 10
Fossil Energy Use

Note: The great increase in energy use in the last 150 years has been in part due to the growth in the human population (accounting for one tenth of the increase). The rest of the increase has been due to new technologies using extrasomatic energy as a source of power (mainly in the form of fossil fuels). The increase in energy use is approximately parallel to the increase in carbon dioxide production.

Fig 11
Inequalities in the Anthropocene

Energy Use

Life Expectancy

Fig 12
History of the Biosphere

Fig 13

Extinction of dinosaurs ~ 65 MYr.
Emergence of man ~ 5 MYr.
Early civilization ~ 0.005 MYr.
Stromatolites, Shark Bay, WA

Fig 14
Chlorophyll molecule
Chlorophyll diagram
## A Brief History of *Homo sapiens*

<table>
<thead>
<tr>
<th>Lifestyle</th>
<th>Time (years)</th>
<th>Generations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hunter-Gatherers *</td>
<td>&gt; 200,000</td>
<td>&gt; 8,000</td>
</tr>
<tr>
<td>Agriculture (Holocene) **</td>
<td>&gt; 10,000</td>
<td>&gt; 400</td>
</tr>
<tr>
<td>Cities ***</td>
<td>&gt; 5,000</td>
<td>&gt; 200</td>
</tr>
<tr>
<td>Industry (fossil fuels) **** (Anthropocene)</td>
<td>250</td>
<td>10</td>
</tr>
<tr>
<td>Information Technology *****</td>
<td>50</td>
<td>2</td>
</tr>
<tr>
<td>Sustainocene ??? *</td>
<td>25</td>
<td>1</td>
</tr>
</tbody>
</table>
Hunter-gatherers: evolutionary health principle (Stephen Boyden)
Health in the Anthropocene

- Nutrition
- Metabolic syndrome (obesity, etc)
- Sugars and refined CHO +++
- Saturated fats ++
- Exercise (*Homo sedentarius*)
- Much reduced in work, transport, recreation

Fig 21
Political ‘Triumphs’ of Anthropocene over Sustainocene

- LARGE COAL SUBSIDIES
- RISING CO₂ EMISSIONS
- NEW COAL MINES, COAL SEAM GAS FRACKING
- DEGRADATION OF SOILS AND ECOSYSTEMS
- DREDGING NEAR GREAT BARRIER REEF
- CONTINUING DEFORESTATION
- NEGLECT OF RAIL INFRASTRUCTURE
- NEGLECT OF RENEWABLE ENERGY POTENTIAL
- NEGLECTED SUSTAINABLE HOUSING/AGRICULTURE
- UNDERMINING SUPPORT FOR SUSTAINOCENE
- DENIALISM
“Achievements” of the Anthropocene

• SPECIES EXTINCTION : 30,000pa
• POLLUTION pa: 10bt CO$_2$, 121mt N, 10mt P
• GLOBAL TEMP. RISE ? 4-5°C BY 2100
• DESTRUCTION OF SOIL, WATER, ENERGY
• PEAK FISH: 2004; PEAK OIL: 2006
• OCEANIC “DEAD ZONES” > 400
• ARMS EXPENDITURE $1.6 Tn pa
• “PEAK OIL”
• ?? HUMAN POPULATION TO 9 Bn BY 2100
• ?? WAITING FOR THE FOUR HORSEMEN

Fig 23
Impacts of Anthropocene on Human Health

- **Advantages**
  - Decrease in maternal deaths: doubled life expectancy
  - Generally improved material living standards
  - Improvements in public health, medical care

- **Disadvantages**
  - Epidemic - metabolic syndrome of obesity Type 2 diabetes, cardiovascular disorders
  - Emerging infectious diseases, antibiotic resistance
  - Drug and alcohol abuse
  - More cancers, apparent mental and social disorders
  - Effects of global warming (extreme weather events etc.)
Impacts of Anthropocene on Human and Planetary Health

- Extreme weather events – habitat loss, hyperthermia, stress
- Emergence of vector-borne and water-borne diseases
- Rioting, warfare for resources
- Breakdown of social and material infrastructures
- Economic collapse – national, personal
The Olduvai Theory of Industrial Civilization

Pre-Industrial Phase [c. 3,000,000 BC to 1765]
A = Tool making begins (c. 3,000,000 BC)
B = Fire use begins (c. 1,000,000 BC)
C = Neolithic Agricultural Revolution (c. 8,000 BC)
D = Watt's steam engine, 1765
Interval D-E is a transition period.

Interval D-E is a transition period.

Peak Oil
Towards the Sustainocene
A TIPPING POINT FOR HOPE

From 19th century ancient, dirty, non-renewable solar CAPITAL

To 21st century clean renewable solar CURRENCY – a new industrial revolution:

- **Local**: Building design and operation (insulation, solar hot water, photovoltaics), biofuels
- **Central**: Solar Thermal Electricity (STE): covering 0.5% of deserts with mirrors focused on turbines would meet all electricity needs. Also geothermal; wind; waves; tides

Fig 27
Towards the Sustainocene

A TIPPING POINT FOR HOPE

- **Transport:** From road to rail, from air to wind-assisted ships; hybrid cars; biofuels from algae and crop wastes, not from food crops or palm oil from cleared forests; Solar or wind-generated H$_2$ in fuel cells

- **Agriculture:** Cease land clearing; move to organic agriculture for better water retention, less pesticides, herbicides; local food production to reduce transport costs

- **Health:** Equity of resources; healthy nutrition; more use of muscle power; adaptation to inevitable global warming (Lovelock)
Message from Bhutan for Rio+20 (2012)

• Aim for growth in happiness, not GDP
• Bhutan’s “Happiness index” top in Asia
• Life expectancy doubled in 50 yrs
• 99% of primary age children in school
• Aims 60% of country to remain forested
• Aims to preserve rich biodiversity
• Bhutan vows to always be a carbon sink
• Aims to be 100% organic in agriculture
Shortcomings of Bhutan

- Bhutan is one of the ‘poorest’ countries
- 25% of its people live on < $1.25 a day
- 70% without electricity
- World’s poorest 20% consume 1% goods
- Richest 20% consume 86% goods
- World’s poorest emit 2% GHGs
- Bhutan has ethnic human rights issues in expelling > 100,000 settlers to refugee camps in Nepal, looked after by UNHCR
Mirrors can light up the World
Solar Plant in the Mojave Desert, California

Fig 31
Solar furnace (French Pyrenees) - 3,800°C
Fresnel linear solar collectors

Fig 33
Future 177 MW Plant, California (Linear Fresnel Reflector)
AREVA Solar Thermal Electricity (Chinchilla, Qld) 250 mW
Solar Dawn – 250 MW (Qld)

Fig 36
STE Sustainocene for USA (Mills)

- Solar collecting and storage square FOR GRID with 153km sides, would replace 2.3 billion tonnes of CO₂ equiv.
- Theoretical electrical replacement of entire VEHICLE fuels would save an additional 2.0 bt of CO2
- Replacement of fossil fuel energy for GRID PLUS VEHICLES by STE in USA would save 4.3 bt CO₂ = 17% of global emissions reduction required.
- Estimated costs for USA to replace static + vehicle loads
  - Future US $1500 per peak kW = c. $723 bn - $1566 bn capital investment, cf $482 bn pa for imported oil (05-06)
  - Payback time would be 1.5-3.0 years, with additional environmental, health and global benefits

Fig 37
Micro - Sustainocene

Fig 38
Agents of the Anthropocene

(The Five "Ps")

POPULATION
POVERTY
POLLUTION
PROFIT
PREPARATION FOR WARFARE
Agents of the Sustainocene

(The Four "Es")

ENLIGHTENMENT
ECOLOGY
EDUCATION
ETHICS
The ABC of Enlightenment

A W E

B E A U T Y

C A R I T A S (Care and active responsibility for people and nature)

Fig 41
Homo sapiens or Homo hubris?

The Cerebral Cortex Contains $10^{11}$ neurones. There are $10^{29}$ possible inter-connections.
The Horsehead Nebula

We are children of the universe

Fig 43
We are creatures of the biosphere.

(one of millions of other species)
“Lifesaving Energy”

Spelled out by 3,000 Bega residents on Tathra beach

Fig 45
“To Our Future” (Translation)

Fig 46

Spelled out in Mandarin by Narooma High School students
"The Creation of "[A]NESIDORA" (Pandora) on a white-ground kylix by the Tarquina Painter, ca. 460 BC. British Museum. A pithos from Crete, ca. 675 BC. Louvre.

Fig 47
Sir, watch starboard bow!!!

Please wait! we are just holding a conference on iceberg avoidance

BALI Fig 48
Spes or "Hope"; engraving by Sebald Beham, Germany c1540

Fig 49
We must save this planet - It's the only one with chocolate!

THANK YOU