

## Note Changes in Definitions:

The term **Geoengineering** has been replaced in some reports by the term **Climate Remediation (2011)**. The Term **Solar Radiation Management (SRM)**, in 2011, was changed in some reports to **Sunlight Reflection Methods** in some report to **Solar Geoengineering (2012)**.

## Definitions & Brief History of Geoengineering – Tyndall Report June 2012

(\*This Report is Worth Reading)

Use the link below to read the entire report:

<http://tyndall2.webapp3.uea.ac.uk/sites/default/files/twp153.pdf>

### “...DEFINING GEOENGINEERING

(Submitted and under review with WIREs Climate Change)

The idea of control over the Earth’s weather and climate predates the modern concept of ‘geoengineering’ by millennia (Fleming, 2010). It has a rich history in ancient mythologies and religions, including those of Ancient Greece and the Roman Empire. Once powers bestowed by gods, control over weather and climate is now sought through technology. Indeed, this hubristic shift in humanity’s relationship with nature was presaged by renowned physicist of Ancient Greece, Archimedes, who is believed to have said: ‘Give me a lever long enough and a place to stand, and I will move the world.’

Following the discovery of the greenhouse effect in 1824 by Joseph Fourier and its later experimental demonstration by John Tyndall; in 1908 Svante Arrhenius proposed deliberately enhancing the greenhouse effect by burning more fossil fuels to enhance agricultural productivity (Arrhenius, 1908).

**Political as well as academic interests in potential weather and climate control ensued during the early to mid Twentieth Century, eventually reaching its height in the Cold War.** Concerted proposals to ‘optimise’ weather and climate during this period (e.g. Rusin & Flit, 1960; Willoughby *et al.*, 1985), were, however, followed by **proposals to weaponise it during the Vietnam War.**

**The controversy that followed and was sustained by the emergent environmental movement led to the signing of the United Nations (UN) international treaty, the Convention on the Prohibition of Military or Any Other Hostile Use of Environmental Modification Techniques (ENMOD) (UN, 1976). The Convention, however, specifically reserved the entitlement to use weather and climate modification ‘for peaceful purposes’ (Article 3.1), helping to maintain modest academic and political interest following the discovery of anthropogenic greenhouse gas induced climate change in 1960 by Charles Keeling (Keeling, 1960).**

Indeed, climate modification techniques were initially the only responses to climate change under consideration (President’s Science Advisory Committee, 1965); with no mention of what has now

become the dominant –even totalising – policy discourse: reducing fossil fuel consumption (mitigation) (Keith, 2000).

The term ‘geoengineering’ was coined in the early 1970’s by Italian physicist Cesare Marchetti and later formally published in the inaugural issue of the journal *Climatic Change* in 1977 to describe a method for ‘disposal’ of atmospheric CO<sub>2</sub> through injection into sinking thermohaline oceanic currents (Marchetti, 1977). The term is a compound noun derived from the prefix ‘geo’ from the Greek *gē* meaning ‘Earth’; and the noun ‘engineering’ meaning the ‘application of Submitted and under review with WIREs Climate Change science to design’ (Oxford English Dictionary).

**Until recently geoengineering has been absent from common dictionaries due to its origins and confinement within the epistemic discourses of Earth system science and related academic disciplines.**

Following its deployment by various actors and emergence in public discourses on climate change, in June 2010 the term was considered to warrant a common definition in the Oxford English Dictionary. However, defining geoengineering is of course somewhat more complex than the Oxford English Dictionary’s modest offering (see Table 1).

Here we begin to map out the complex etymology of geoengineering, revealing ambiguities as to what: i) constitutes geoengineering; ii) best delivers a linguistic framing; and iii) segregates its subset-classes.

**Table 1 – Selected definitions of geoengineering  
Listed by Source & Definition of ‘geoengineering’**

**NAS (1992)**, p 433 - ‘[Geoengineering proposals] involve large-scale engineering of our environment in order to combat or counteract the effects of changes in atmospheric chemistry.’

**Keith (2000)**, p 245, 247 - ‘Geoengineering is the intentional large-scale manipulation of the environment... For an action to be geoengineering, the environmental change must be the primary goal rather than a side effect and the intent and effect of the manipulation must be large in scale, e.g. continental to global... Three core attributes will serve as markers of geoengineering: scale, intent, and the degree to which the action is a countervailing measure.’

**Barrett (2008)**, p 45 - ‘[Geoengineering] is to counteract climate change by reducing the amount of solar radiation that strikes the Earth... [not] by changing the atmospheric concentration of greenhouse gases...’

**AMS (2009)** p 1- ‘Geoengineering – deliberately manipulating physical, chemical, or biological aspects of the Earth system [to reduce the risks of climate change].’

**Royal Society (2009)** p ix - ‘...the deliberate large-scale intervention in the Earth’s climate system, in order to moderate global warming...’

**Oxford English Dictionary (2010)** - ‘The deliberate large-scale manipulation of an environmental process that affects the Earth’s climate, in an attempt to counteract the effects of global warming.’

Whilst most are in agreement that for an action to constitute geoengineering it must be large in scale (cf. MacCracken, 2009), ambiguities exist relating to the issue of intentionality. For Keith (2000), an action constitutes geoengineering when it is large in scale (e.g. continental to global manipulation) and intentional and countervailing in nature. On the other hand, others argue that neither intentionality nor a countervailing nature is a useful criterion for constituting an action as geoengineering. Fleming (2010) points out that those criteria should not be used to constrain actions already defined by their scale, and which could lead to undesirable as well as desired countervailing ends. Indeed anthropogenic climate change itself has been considered to be inadvertent geoengineering (NAS, 1992).

**Ambiguities as to what best delivers a linguistic framing for geoengineering and its subset-classes often relates to preferences or semantics.** The term geoengineering has been – and still is to some extent – competing with a host of alternative terms, including ‘climate modification’ (e.g. McCormick & Ludwig, 1967), ‘climate engineering’ (e.g. Bodansky, 1996), ‘Earth systems engineering’ (e.g. Schneider, 2001), ‘planetary engineering’ (e.g. Hoffert *et al.*, 2002), and most recently ‘climate remediation’ (BPC, 2011).

**Climate remediation is a particularly interesting case as it represents an attempt to ‘rebrand’ geoengineering. It was chosen by some to sit more comfortably alongside the more conventionally termed ‘mitigation’ and ‘adaptation’ strategies (BPC, 2011), but it did not go unopposed in its adoption (see Sarewitz, 2011).**

Similarly, within its subset-classes the term **SRM (Solar Radiation Management)** has been rebranded ‘Sunlight Reflection Methods’ due to concerns over its emotively provocative predecessor ‘Solar Radiation Management’ (see SRMGI, 2011). Others have simply used ‘geoengineering’ itself to refer solely and explicitly to solar geoengineering proposals – and in particular stratospheric aerosols – ignoring carbon proposals in the definition altogether (see Barrett, 2008).

Ambiguities as to what segregates subset-classes of geoengineering often relate to proposals’ technical and political implications. The UK’s Royal Society (2009) has provided perhaps the most widely accepted definition of geoengineering, having been reaffirmed by the UK Government (HoC

IUSSC, 2009) and the Intergovernmental Panel on Climate Change (IPCC, 2010) among others. This authoritative report divides geoengineering proposals along technical lines into two classes: Carbon Dioxide Removal (CDR) techniques and Solar Radiation Management (SRM) techniques. The same report recognises to a lesser extent a further taxonomic division between geoengineering proposals: those pertaining to Earth systems enhancement or traditional ‘black-box’ engineering (Rayner, 2011).

Others have divided proposals along similar lines but included a third class of ‘other’ proposals (AMS, 2009); whilst others still have further divided those subset-classes into sub-subset-classes based on the broad Earth systems they seek to manipulate, including the top of the atmosphere, atmospheric or surface albedo, land or ocean (Lenton & Vaughan, 2009) and surface albedo modification (SAM) (Irvine *et al.*, 2011). Some divide proposals differently altogether, according to their ‘commons’ or ‘territorial’ governance implications (Humphreys, 2011).

Here we have begun to map out the complex etymology of geoengineering and revealed some of its ambiguities. Indeed this is reflected in the varied public understandings of the term, where just 8% of Americans, British and Canadians are able to ‘correctly’ define geoengineering (Mercer *et al.*, 2011).

**Whilst recognising the ambiguities of geoengineering, for clarity this review will use the term to refer to deliberate large-scale intervention in the Earth’s climate system in order to moderate climate change; and ‘carbon geoengineering’ and ‘solar geoengineering’ to refer to classes of proposals which seek to remove and sequester CO<sub>2</sub> from the atmosphere and to increase the reflection of sunlight back into space, respectively...”**