State of the Nation
Nation in a State

MINORITY REPORT ON GLOBAL WARMING
AND THE ROLE OF CIVIL ENGINEERING
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This paper highlights the reality beneath the professed action to limit global warming. Civil engineers control key sectors such as construction, transport, water supply, power, drainage and flood defences, all of which affect, or are affected by global warming.

There is little scope for rational doubt that recorded global warming and measured rapit growth in atmospheric carbon dioxide are linked. It follows, as confirmed by analytical models, that the extent of devastation due to warming in subsequent decades will be largely determined by the success or failure to reduce greenhouse gases in the next year or so. Scientists say that they have provided the data and can do little more; it is now up to politicians and engineers to act.

While politicians initially acknowledged the problem to be faced, civil engineers have generally denied the issues and the majority of working civil engineers, along with many eminent statesmen, advocate the "do little and do it slowly" option. Yet civil engineers claim credit for initiating the first industrial revolution, and with a new attitude, could now help the nation prepare for the dramatic changes that appear to be inevitable sooner or later.

1 Attitude of the Civil Engineering Professional to Global Warming

1.1 All the key political leaders have at some time agreed that "Global Warming is the biggest threat to mankind" yet British professional engineers, after over a decade of warnings, still advocate emission targets for dates such as 2020 or 2050, which are beyond the relevant timescale and at emission levels considered by many to be far too high. The Institution of Civil Engineers (ICE), who used to define civil engineering as "the art of directing the great sources of power in nature for the use and convenience of man" has produced an annual "State of the Nation" report on the UK's infrastructure. This has consistently reflected a cynical "business as usual" approach with little or no references to Climate Change in the main document.

1.2 The risks are unacceptably high that any remaining timescale to take effective measures is restricted to just a few years if climate change is to be limited. The well-published and negotiated predictions, by their nature, understate the dangers so it is utterly foolish to rely on future possible solutions as a panacea, while we allow green house gases continue to rise. To quote one ICE Council member "If we wait for the silver bullets, then we are doomed."

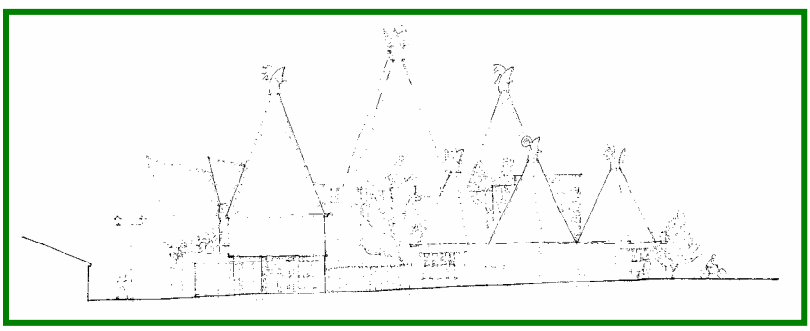

Figure 1 – Suggested rustic architecture for Doncaster Church Buildings would allow use of low emission materials that could have a negative carbon footprint with natural ventilation (by Wiles and Maguire Architects). Many buildings could be cooled without air conditioning.

1.3 This memo therefore highlights some of the extraordinary engineering issues that need to be considered by engineers and society in general if rational scientific recommendations to cut carbon emissions by 60% to 80% forthwith are to be attempted. These throw up challengers to many long-held beliefs and values. The review considers:

(a) How can growth in UK emissions be reversed within the timescale dictated by the laws of physics and chemistry.
(b) How can carbon be locked up for the foreseeable future?
(c) In any engineering cost/risk analysis, is it acceptable to take account only of British lives now, when any project will be paid for by the lives of the younger generation and those elsewhere in the world?
(d) How should attitudes, Codes of Practice and policies then evolve?
(e) How then might technology adapt to change?
(f) How and why does the UK have a pivotal role?

1.4 Although nothing is precise about global warming, engineers are used to assessing risks and taking appropriate measures, even when the odds of accidental conditions are in the region of 1:10,000 where British lives are at stake. Data is not easily available, but the risk of runaway climate change, with almost total loss of humanity, might have been given a probability at least in the region of 1:5, if not 4:5 if current trends continue. This would indicate a "High Probability" with a "Very High Risk" in any Health & Safety review, which would be unacceptable in any project design.

2 Buildings Bridges and Other Structures

2.1 The importance of structural engineering in fighting climate change is indicated by the statistic that production of cement alone causes 5% of greenhouse emissions. Engineers have major roles in specifying both the capital carbon footprint and the environmental running costs.

2.2 In house designs, the former Office of the Deputy Prime Minister made positive changes to the Building Regulations to start steering buildings towards sustainable products and effective insulation. However, many commercial buildings tend to be extravagant, and inappropriate designs for new buildings continue to rely on massive energy consumption, particularly for cooling. There is much scope to revisit buildings from the Georgian to Edwardian eras, as these often incorporated vents and double-opening sash windows that could provide heat-driven natural ventilation (Figure 1).

2.3 In construction, there has so far been little restriction in the use of very high emission industrial products such as:

(a) concrete foundations
(b) kiln-fired brick and concrete walling blocks
(c) steel or concrete frames
(d) concrete suspended or ground-bearing floor slabs
(e) glass, aluminium or steel cladding
(f) concrete roof tiles or steel profile sheeting

Figure 2 – A simple hardwood timber frame replacing steel saved 16 tonnes of CO_2 in this building.

2.4 Buildings, which currently have large carbon footprints could be redesigned to have negative carbon footprints. For an increased financial cost, most high-energy materials could be replaced with natural products and the high emission products could be restricted as "dangerous" products. There would need to be reassessment of short-term risk and long-term risks:

(a) The use of steel should be restricted, particularly when imported from inefficient coal-burning producers. Some engineers argue that steel is "sustainable" because it can be re-used, yet with demand far outstripping scrap supplies, this dangerous folly should be disputed. Building layouts could be easily adapted for timber spans (Figure 2).

(b) The use of concrete is considered almost mandatory under the current Codes of Practice and Building Regulations, particularly in foundations, yet throughout the medieval period other techniques were employed. These even allowed construction of massive cathedrals with enormous bearing pressures using stone and timber in the foundations and floor slabs (Figure 3).

Figure 3 – Stone foundations have been adequate to support high loadings for hundreds of years

2.5 Similarly, bridges and viaducts, sports stadia, retaining walls, flood defences, canals, lock gates and roads reservoirs were all constructed without significant use of concrete or steel up to the late C18th. Engineering would need to rise to the exciting challenges associated with re-learning traditional approaches while developing new harmless methods of construction.

2.6 Clients, particularly government authorities need to change their expectations. For example, there is little point in highway bridges still being designed for 120-year life spans when the probability of civilisation itself surviving is low. The use of any high emission materials should be restricted to special projects that can justify the need over the next ten years against the damage imposed on the planet over the next century.

2.7 Timber is not only a recognised sustainable structural material, but use of chunky timber in our buildings is one of the few easy and positive measures that can be used to remove carbon from the system and lock it up for a relatively long period. At present, very little British hardwood is used in construction, and as trees only absorb carbon from the atmosphere up to reaching maturity, there is a positive need to make the best use of timber stocks that were planted in previous centuries. This will again require creation of a totally new exciting industry based on new research and forgotten historical techniques (see GreenBeams.com).

3 Road Transport

3.1 Civil Engineers have previously advocated road pricing to reduce congestion even though use of such taxing methods could not quickly cut carbon emissions and would be too socially divisive for any democratically elected government. Recent advice to government involves reliance on new vehicle technology and setting targets for 2020. It was again only the minority report that pointed out that drastic cuts are needed now, not gradual reductions in future decades. Even without air travel, transport emits 26% of CO_2.

3.2 Reducing greenhouse gasses quickly to 10% of current values would be a logical target, which would mean that use of hydrocarbons such as petrol, diesel and gas will need to be almost completely restricted. Engineers should prepare accordingly for a form of wartime rationing and command economy, at least for an initial period of say five years. Firm warning of such carbon rationing would allow individuals and corporations to start planning for changes in lifestyles and for shifts in infrastructure requirements. These would create many new and different engineering challenges.

4 Public Transport

4.1 Rationed fuel would precipitate demands for a very much better and integrated public transport network. It would not only need to cope with many times the existing capacity, but it would need to serve wider sections of society and reach new locations.

4.2 For short-distance travel, the bus system has proved to be the most cost effective form of transport. Although few buses at present are environmentally ideal, and there is much scope for modern communications to create a very different bus service (Figure 4).

Figure 4 – Bus Station under construction in Sunderland

4.3 Light rail networks have proved difficult to justify on financial grounds in the last decade, so it is unlikely that many new major underground schemes could prove a negative carbon footprint in the short-term. However, there is much scope to reintroduce and upgrade rail and tram routes which would be very viable once car use is restricted.

4.4 For longer distances, without competition from roads and flights, the railways would also face the need to accommodate more frequent trains at a diverse range of stations, alongside a massive increase in passenger numbers plus demand for freight services. This would require a completely different set of strategic targets from the current priorities.

(a) Rail engineers would need to combat pressure from the media, politicians and the law that requires rail travel to be so much safer than other forms of transport. Saving lives from global warming and road use will have an inevitable impact on the frequency of rail crashes.

(b) Speed of some trains might need to be cut to fit in extra rail traffic, and journey times might become less important.

(c) Alterations to the line and even regular maintenance will be difficult to timetable, especially when freight takes up any quiet periods.

4.5 In advance of the anticipated pressure on rail, engineers need to order new stock and prepare. This will often involve undoing measures that were taken in the 1960s and 80s regarding closed sections of line, freight sidings, points for slow running lanes and extra platforms that are currently being used as car parks.

4.6 Proposals for new lines such as the monorail need to be re-evaluated based on likely future scenarios instead of current conditions.

5 Air Travel

5.1 The 2006 State of the Nation report called for expansion of air travel and "continuing research into climate change, atmospheric science, emissions trading and new technologies to make future air travel more sustainable." As scientists argue that air travel effectively contributes around 20% of current emissions and with stark consequences looming for inadequate remedial action, such advice from the ICE appears reckless. Air travel is likely to be a luxury that can be easily cut by developed society, although the impact on developing countries will be very significant.

6 Waste Management

6.1 The 1990's EEC legislation to cut landfill illustrates one area where politicians, civil engineers and the public have enthusiastically exerted themselves on an environmental issue. The concept of cutting down on wasteful production to reduce landfill throughout Europe may also have some beneficial effect on greenhouse emissions.

6.2 A check is needed however to ensure that such recycling measures are reducing rather than contributing to carbon emissions over the crucial period of the next few years. There has been little debate over how landfill itself might have been beneficially locking up carbon. Rubbish decays very slowly in many tips, so that carbon is effectively removed from the environment for the critical period of time. Landfill is particularly beneficial when compared with composting which produces methane that is 23 times more harmful than if the material was simply burnt.

6.3 There is also concern that current re-cycling schemes, which reduce door-to-door refuse collections, tend to increase the number of car journeys to the recycling centres. All measures should be reviewed against carbon emissions.

7 Power

7.1 The shortcomings of nuclear power are well known, but humanity could survive many nuclear catastrophes, while few would survive runaway temperature change. The key

question would be the cost-benefit of construction in terms of carbon balance if the crucial period to cut emissions falls within the next five or so years.

7.2 The timeframe to find and execute solutions for long-term storage of existing waste is becoming critical. While structural designs seek for risks around 1:10,000, the probability that stable national government will survive the effects of climate change must be much less than 1:100 and responsible management of nuclear waste then becomes difficult to control, as illustrated by the changes in political and economic regime in the USSR.

7.3 While national schemes for power generation are needed, locally owned schemes, initiated from Parish Council level for perceived local use will often be socially productive so long as maintenance can be assured. There are major impediments to wide-scale production of electricity at local level and these can be best considered in the light of C19th power generation before national electricity:

(a) Much use was made of natural resources of wind and waterpower. These were particularly available in upland areas that have subsequently become National Parks or similar. Short-term planning consents are needed to meet the current crisis over runaway climate change.

(b) Many estates created inefficient, yet usable, hydroelectric systems with large dynamos. This water is now controlled by landowners, large corporations, government agencies and acts of parliament, all of which tends to prevent the rapid setting up of small hydroelectric projects. Compulsory leases should be available.

(c) The historic and resourceful use of waterpower has also been restricted by The Reservoir Act, which legislated against using dams to regulate and store water without major “red tape”. As part of a review of risk and liability to UK citizens in the light of global warming, the restoration or creation of storage ponds should be based on designs using reasonable risks assessed by a non-specialist civil engineer.

(d) Despite massive advancements, C19th generation infrastructure is perceived as too small and inefficient to resurrect, yet at the other end of the scale hand-held generators for wind-up torches are now commonly available. Development of simple, low-cabon generators using mostly recycled materials, which can be used throughout the country is clearly an area where government grants would soon create a marked change.

7.4 The problems associated with producing power, which need input from several types of engineer, highlight the problem of current training at universities. More courses need to cover the theory of all aspects of engineering to enable graduates to be able to assist a very different world from the currently specialised society.

8 Coping With Current Changes to the Environment

8.1 Engineering designs are presently carried out using statistics and perceptions of risk that current scientific predictions would invalidate. The major new issues that the government and the courts need to consider are:

(a) Risk Assessments for British Projects, as currently required by law, should encompass the long term loss of life to others around the world based on simple applicable of carbon emission equations.

(b) The value engineering of work on roads railways etc to save a British life now should include the carbon cost to the younger generation.

(c) In a changing world, life expectancy for projects should be foreshortened so that realistic payback periods in terms of carbon savings and cost are based on no more than four for five decades.

8.2 Flooding of property has already been a concern for insurers and planners. This arises from three different but perhaps overlapping sources.

(a) Rises in sea level. Although many scientists suggest rises of 7.5m are almost inevitable at some point, current data indicates a rise in sea level of only 200mm in this century. Major sea defences that produce extra CO_2 are therefore not currently warranted, particularly if they create further warming.

(b) Flooding of rivers. This is an area where engineers have accepted the scientific data on climate change and are calling for extra funds.

(c) Surface runoff. Many properties, even on high ground are at risk against tropical-type storms. These are now relatively frequent in parts of the UK, where 75mm of rain can now fall in just 15 minutes. The effect of roads

Figure 5 – Debris caught in branches during a 3m deep flood in 2005

turning to rivers and manholes to geysers should be considered for all new and existing developments, as solutions are often simple and cheap.

8.3 For the short-term, many simple savings are not being adopted, particularly to help buildings adapted to cope with the predicted heat.

(a) Many modern buildings have air conditioning that cannot cope with the extravagant extent of glazing in hot weather. An easy solution would be to create new openings that will use the heat to create draft and to switch off the conditioning.

(b) Older buildings from the Georgian, Victorian and Edwardian times tended to have been designed for fresh-air fanatics. Even the small buildings often had ventilation shafts, which have been subsequently closed off. Nearly all buildings had sash windows that by opening top and bottom created drafts but half of which have been subsequently painted shut.

(c) Economic maximising of daylight by changing to European time would offer easy savings at negligible cost throughout the year.

9 Major Projects

9.1 In the next few years, there is every chance that individual projects will be given, not just a carbon footprint, but an equivalent that would be measured in lives destroyed or lost in other parts of the world. High emission projects such as new railway lines would then effectively become an element of a "command economy", limited by justification of the adverse effects.

9.2 Works for preparation for the London Olympics aim to be the most sustainable yet. However, the present aims of prestigious concrete and steel structures with infrastructure to meet all requirements cannot be carbon negative. The aims are likely to straddle the transition in cultural requirements. If present plans are realised then it is likely that the 2012 Olympics could become a major symbol of the West's "carry on regardless" with resulting protests and boycotts. A decision needs to be made whether a "War on Climate" extends into sport and whether global concerns would warrant cancelling or scaling back the games to an acceptable carbon footprint.

10 How and why should the UK seek to influence the rest of the World?

10.1 The UK government was initially in the forefront of campaigning against growth in greenhouse gases, yet direct action has been negligible, with the result that there has been no cut in emissions in Britain, never mind in the rest of the world. No positive action is possible while collective responsibility is awaited.

10.2 There are many reasons why the UK could, and should, lead nations into the post-industrial era:

(a) While many might welcome 2-3 degrees of warming in the UK, such an increase is already assured in the next decade or so, even if greenhouse emissions ceased immediately. It is the further warming and runaway overheating that needs to be prevented at all costs.

(b) Even the most pessimistic forecasts anticipated some levelling off in carbon emissions, yet the almost exponential growth continues to exceed the "worst credible" which means that scope of optimism is reducing each month.

(c) It was Great Britain that started the problem of emissions through the engineering ability of Telford and Hindly, Necomen, Watt and Stephenson. Their efforts allowed mining and transportation of goods that introduced the industrial revolution to the world in the C19th, fed mostly on the burning of coal and oil. Carbon that had been stored over millions of years has been released into the atmosphere at an ever increasing rate.

(d) The British are still one of the highest producers of greenhouse gases per person, despite the closure of the coal industry.

(e) An example needs to be set for both developed and developing nations to illustrate how there are viable economic prospects beyond industrialisation. Developing nations need to be convinced that it is not necessary to industrialise to catch up with the developed nations.

(f) London is one of the world's financial centres, which need not be significantly affected by major changes in life style.

(g) On the other hand, London is also a major hub for air travel, so meaningful change can be instigated to one of the most damaging industries.

(h) The UK will be the centre of attention over the next few years because of the 2012 London Olympics. It is predictable that environmental issues and associated protests will overshadow sport especially if Britain is culpable of dismissing the short-term threat to much of the developing world.

(i) The UK has the political and financial stability, the engineering technology, and even an enormous carbon friendly infrastructure to revolutionise life-styles into the post-industrial age.

(j) Great Britain has often taken the lead in other major moral and social issues such as abolition of slavery and renunciation of colonialism, even when they appeared at the time to conflict with short-term self interest.

(k) The British are likely to accept and morally support difficult measures, so long as they are seen to be necessary, equitable and fair for all, irrespective of power and wealth.

11 Conclusions

11.1 The majority verdict currently being urged on the government by many professionals, including most civil engineers, is that it is better to take little effective action to cut carbon emissions and to aim at low targets, with distant timescales. Deviation from current economic theory is perceived to be more dangerous than the threat of global warming predicted by science.

11.2 Civil Engineers largely control and design our environment yet rarely design in a "sustainable manner". There are few signs of change within the short timescale that appears to be critical. Projects continue to be designed without reference to causes and effects of climate change, for unlikely life-spans, using dangerous materials, using codes of practice that would no longer be relevant if risks associated with climate change were included.

11.3 As greenhouse gas emissions continue to rise almost exponentially, a significant minority of engineers would point out that the laws of physical science cannot be appeased, and that there is little scope for future technology to restore damage if harmful emissions are not brought under control within months rather than decades. The extreme risk warrants drastic action and requires a complete review of previous values. Once this is accepted, then preparations can be made that can give the younger generation the best chance of survival.

11.4 The UK is uniquely positioned to lead the world into a new post-fossil fuel era. Many new skills and industries would need to be set up or re-learnt in a period of rapid change that would offer many new opportunities.

12 Recommendations for ICE

12.1 The debate over whether or not to face up to Global Warming should be brought into the open. In particular for civil engineers who largely control and design the environment of our civilisation, it should be acknowledged that:

(i) British civil engineers are not generally working towards trying to reserve the growth in carbon emissions on current projects, nor for future schemes.
(ii) Many practicing engineers do not believe in climate change or that measures to reduce it are warranted.
(iii) Much of the debate and many articles by professional trade bodies are intended to confuse issues to protect vested interests.
(iv) Those engineers, who seriously suggest low-carbon alternatives, are having negligible impact within the timescale that appears relevant and are usually forced to work with non-sustainable materials for the majority of clients.
(v) Funding and financial incentives to fight climate change appears to have so far been directed towards universities and other institutions rather than the bodies that could directly challenge the processes that generate greenhouse emissions.

12.2 Professional organisations such as the Institutions of Civil Engineers, which are split by members who have extremely different philosophies over climate change, should develop an extra designation for those who wish to work with genuinely sustainable materials. Clients can then choose whether they want a sustainable design or not.

12.3 The direct and indirect dangers from climate change need to be presented as statistical probabilities to engineers and society in general. The threat to the younger generations of the “do little and slowly” approach can then be compared with other currently perceived risks such as terrorism, and a range of other accidents.

12.4 Once distinct civil engineering attitudes have been separated and the statistics have been better defined, it would be hoped that aims and actions would be more transparent. Society should then be given definite choices over whether the British people want to lead the world and improve the chances of the younger generation, or whether they prefer to continue as before. A decision should be made.

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