STRATEGIES FOR RADICAL CLIMATE MITIGATION

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Recent research in climate science, summarised by Allen et al. (2009), finds that to limit global average temperature increases to 2ºC (which is not necessarily safe), humans would have to emit a very limited amount of total CO2 emissions between 2009 and 2050, possibly to the extent that there are zero net emissions in 2050 and beyond. Furthermore, 'given the scientific logic of the cumulative budget, it is also hard to avoid the conclusion that negative CO2 emissions may need to be considered' (Allen et al. 2009).

The present paper offers a broad outline of a technologically feasible, but politically difficult, ecologically sustainable and socially just scenario for achieving zero net emissions by 2050. Australia is chosen as a case study, because it is the highest per capita greenhouse gas emitter in the developed world, being responsible for about 26 tonnes per person per year of CO_2-equivalent emissions in 2008 (Australian Government 2010: 6). If plausible scenarios can be developed for eliminating all of Australia's emissions, then it could be argued that most other developed countries could do it too. Reducing Australia's net emissions from 26 tonnes to zero would entail huge changes in the energy system, industry and land use, both in supply and demand. This would in turn involve a transformation of the nation's economic structure. It is unlikely that these changes could be achieved without a political struggle between a citizen-based social movement and powerful vested interests (Diesendorf 2009).

This paper commences by outlining a scenario for the radical mitigation of climate change by means of an ecologically sustainable and socially just development pathway to 2050. To clarify the nature and context of the problem, the paper identifies and assesses the principal drivers of anthropogenic climate change, outlines strategies and policies for addressing these drivers, and discusses the political challenges facing in implementing effective policies. Along the way, the paper critiques the notion that a system of decentralised energy technologies is adequate system for a contemporary sustainable society.

Sustainable Society Scenario

There are many different visions of an ecologically sustainable and socially just society, some fictional (e.g. Huxley 1962; Callenbach 1977; Piercy 1977; Quinn 1992), some from governments (e.g. ESDN website) and others scholarly (e.g. Sachs *et al.* 1998). The one outlined in this paper focuses on achieving a sustainable climate and is concerned primarily with the Australian national scale, while briefly visiting the international. It is described in some detail, because some future pathways are simply labelled as 'eco-sufficiency' (e.g. Salleh 2009) without defining them.

In the present scenario the rich countries have taken the first step in an international process of Contraction and Convergence (Global Commons Institute undated). They have stabilised their growth in economic activity and population, and reduced their per capita greenhouse gas emissions. Eventually, in 2050, all countries had converged to the same level of per capita emissions compatible with climate stabilisation, close to zero. To avoid giving countries a perverse incentive to increase their populations and hence their total emissions, per capita emissions have been calculated on the basis of 2010 populations.

In 2010, there were not many published scenarios of societies with 100% renewable energy and (understandably) few of these studies offered an economic analysis. On a global scale, the studies by Sørensen and Meibom (2000) and Jacobson and Delucchi (2010) presented evidence and arguments that 100% renewable energy was possible, provided renewable energy could be traded between countries. Other global scenarios, in which renewable energy contributed about 80% of energy supply by 2050, were published by the Energy Watch Group (Peter & Lehmann 2008) and Greenpeace (Teske & Vincent 2010). On regional and national scales, there were 100% renewable energy scenarios for Europe (Lehmann & Drees 1998; EREC 2010), northern Europe (Sørensen 2008a), Britain (Centre for Alternative Technology 2010), the USA (Makhijani 2007), Denmark (Lund & Mathiesen 2009), Japan (Kruska *et al.* 2003), New Zealand (Mason *et al.* 2010) and Australia

(Wright & Hearps 2010). The principal method of constructing these scenarios was described in detail by Sørensen (2008b).

The sustainable society discussed in this paper is a vision and an outline of assumptions rather than a detailed scenario of demand and supply. An important feature is that it has a steady-state economy – that is, one with no growth in the use of energy, materials, people and land; and with very low throughput of energy and materials. While markets still exist in the scenario, they are tightly constrained to limit the accumulation of individual and corporate wealth and so it is debatable whether the economic system can still be described as capitalism. The system of governance is democratic, with a greater degree of citizen participation in decision-making than the 2010 system in Australia, and is also designed to discourage the growth and existence of powerful elites.

Most people live in compact cities with a mix of high- and medium density housing and with excellent public transport, cycle-ways and pedestrian areas (Newman & Kenworthy 1999; Newman 2008). The railway network allows ready access to national parks and garden allotments outside the city, as in Amsterdam of 2010. There is negligible use of fossil fuels and negligible greenhouse gas emissions. Private motor vehicles for urban use are 'fuelled' from electricity generated by renewable sources. Long-distance motor vehicles are fewer in number and are run on biofuels produced sustainably. Chemicals are also produced from sustainable biomass. Some energy is generated locally within the city from solar hot water, solar PV and combined heat and power fuelled by biomass. However, most energy is generated outside the city by large solar power stations on marginal land; wind farms coexisting with food production on agricultural land; biomass (based on residues of crops and plantation forests) producing electricity, heat and a limited quantity of liquid fuels; and hot rock geothermal power stations in the outback (Diesendorf 2007a). The centralised component of energy is transmitted to end-users by powerline and pipeline. Some fruit and vegetables are grown within the city, but most on the allotments. Grains and other staple foods are still grown in rural areas.

Although this sustainable society is rather industrialised and centralised, it has no biophysical growth. It has less social inequality than the present Australian society and is a mix of high-tech and low-tech in terms of scale and complexity of technologies. But without the large high-tech component and international trade in renewable energy, it would not have many of the small-scale energy systems sought by proponents of self-sufficiency. The rationale for this kind of sustainable society is discussed in more detail below. First we must recognise the drivers of ecological unsustainability.

The Drivers of Climate Change

There has been much debate about what the root causes of environmental destruction are in general and global climate change in particular. Is the principal cause the dominant economic system with its emphasis on endless growth; is it population growth, or is it inappropriate technology? According to the framework generally attributed to ecologist Paul Ehrlich and energy expert John Holdren, at one conceptual level the drivers of environmental impact are all three factors: inappropriate technology *T,* growth in consumption per person (aka 'affluence' *A*) and growth in population *P*. Environmental impact *I* can be disaggregated into the well-known identity:

$$I = P\ A\ T \qquad (1)$$

If consumption is measured by GDP, then $A = (GDP)/P$ and $T = I/(GDP)$.

Underlying the three drivers of climate change are cultural factors and the lust of some people and organisations for wealth and power. Since these are difficult to measure and change, this paper addresses climate mitigation through technology, population and consumption per person.

Within the Kyoto accounting classification, Australia's 2008 emissions of 576 million tonnes of carbon dioxide equivalent (CO_2-e) per year arise from energy (72%), agriculture (15%), land use, land use change and forestry (5%), industrial processes other than from energy use (5%), and wastes (2.5%) (Australian Government 2010: appendix 2, table 1). Since energy is by far the biggest contributor to Australia's and indeed the world's emissions, it must receive the principal attention in a mitigation strategy.

In the particular case of climate impacts from energy generation and use, we can choose carbon emissions *C* as a proxy for environmental impact *I,* 'affluence' *A* to be represented by energy consumption per person (E/P) and the technological choice *T* by carbon emissions per unit of energy use (C/E). Then identity *(1)* becomes:

$$C = P\ (E/P)\ (C/E) \qquad (2)$$

In the disaggregated version *(2)*, each of the three factors on the right-hand-side is important, to the extent that doubling any one doubles carbon emissions and hence impact. Each factor can be measured and each requires separate policies to reduce it. Policies to stop population growth are different from policies to stop growth in per capita consumption, and both are different from policies to change technology. Therefore, this disaggregation offers a useful framework for developing practical policies and programs.

The identity *(2)* also brings together the effects of energy supply (technology choice) and energy demand (consumption per person). Clearly technological change is vital to address energy supply. Indeed, in the limiting case when all energy supply comes from renewable sources, there would be zero greenhouse gas emissions from the energy sector. Therefore, authors who attempt to dismiss the role of technological change in combating emissions (e.g. Trainer 2008; 2010) are mistaken, since technology is a vital part of the equation, especially for reducing the dominant source of greenhouse gas emissions, the energy sector.[1]

Attacking the Drivers of Climate Change

What kind of technology (interpreted broadly) is appropriate for an ecologically sustainable, socially just society with a steady-state economy and population? In the energy sector, to minimise greenhouse gas emissions and the risk of nuclear war, the only option is a renewable energy system used efficiently.

Even in a 100% renewable energy system, endless growth in energy demand and supply would entail that the wheels of industry and vehicles would turn faster and faster. Non-energy industrial greenhouse gas emissions, which are currently relatively small, would increase. Even worse, broader environmental impacts – on biodiversity, soils, water consumption, and air and water quality – would escalate. To achieve ecological sustainability, energy demand, and indeed the demand for more and more stuff, must be stabilised. While new technologies can

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1 Trainer's claims that renewable energy cannot sustain, either physically or economically, an industrial society, are contested elsewhere (Diesendorf 2006).

play a major role in improving the efficiency of energy use, that potential is limited. Also needed is a reduction in the demand for energy services. This can be achieved through changes to the economic system, stabilisation of population and cultural changes. Authors who claim that technology alone can solve the major environmental problems are also mistaken.

So, climate mitigation entails working simultaneously on all three fronts to defeat anthropogenic climate change. However, time is running out. We now face the imminent risk of Earth's climate being driven over tipping points into irreversible change (Hansen 2009). Therefore human society must establish priorities in allocating resources. More resources are needed for those response measures that can be implemented most rapidly with least harm to people and the planet. Value judgements, informed by the best available science and social science, cannot be avoided.

In the energy sector, responsible for roughly 39% of global emissions (IPCC 2007: fig.TS.2b) and 72% of Australia's emissions, the fastest and cheapest response measures are efficient energy use and solar hot water (mostly technological) and energy conservation (mostly behavioural).[2] These measures can actually save money, which could be transferred to help fund the next fastest measure, the implementation of renewable energy technologies that are either already commercially available (wind power, combustion of biomass residues, solar photovoltaic systems) or semi-commercial (concentrated solar thermal power with thermal storage). These measures, together with others in the non-energy sectors, could possibly reduce Australia's total greenhouse gas emissions by 30% (Diesendorf 2007b) or even 40% (Teske & Vincent 2008) by 2020.

In the land use sector, the fastest and cheapest measure within Australia could be the termination of native forest logging together with the expansion of plantation logging on land that has been previously cleared. This would account for about 50 megatonnes or 8.7% of Australia's emissions (Australian Government 2010: appendix 2, table 6). Financial assistance would be needed to facilitate a just transition for forestry

2 Efficient energy use is defined to be having the same energy services with less energy use, eg by insulating one's home; energy conservation is reducing energy use by reducing one's demand for energy services, eg, by dressing warmly, accepting a lower indoor temperature in winter and heating one's home less.

workers. On a global scale, deforestation accounts for about 17% of global emissions (IPCC 2007: fig. TS.2b). However, ending the global industry is unlikely to be rapid, because of the political power of large national and multinational logging corporations. Reducing the consumption and hence the production of beef and lamb could in theory make rapid reductions in agricultural methane emissions (about 6% of global and 10% of Australian emissions), but in practice runs counter to the existing trend of eating more meat in newly industrialising countries. Changing agricultural practices to no-till forms of agriculture, reduced use of nitrogenous fertilisers and improved management of animal manure could reduce nitrous oxide emissions (about 8% of global and 15% of Australian emissions).

Slowing population growth and economic growth in ways that do not damage people's lives are not measures that could be implemented rapidly, however a start could be made by developing and implementing policies now. Even with an immediate removal of the birth incentives and with dramatic reductions in immigration into countries with high per capita consumption, there would be a substantial time delay before population could be stabilised. The future mothers of the next generation of children are already here. Furthermore, growth in per capita consumption has become deeply embedded in the economic and governance systems, and in the culture of industrialised nations.

Following the Global Financial Crisis, there has been some questioning of consumption growth by a few (e.g. Jackson 2009; Stern 2009; CASSE undated), but even large environmental and social justice NGOs still pay lip service to economic growth. Indeed, one of the principal arguments presented by these NGOs in favour of technological changes is that economic growth will make the cost of such changes relatively small compared with projected future GDP and personal incomes.

Since technological change appears to be easier, faster and already under way, there is a case for focusing on technological change while working at a more measured rate to stop growth in population and consumption per person and to redistribute wealth. In the classification of social movement dynamics of Moyer *et al.* (2001), technological change is at stage 4 'take-off', while ending population growth and economic growth appear to be at stage 2 'proving the failure of official institutions'. Achieving a more just society could be placed at stage 3 'ripening conditions', but it has been stuck there for decades.

The proposed strategy of action on three fronts simultaneously cannot be described accurately as ‘ecological modernisation’, but rather is a mix of elements involving ecologically sustainable technologies, an end to growth in population and consumption in the rich countries, and social justice. Each of these driving forces is next examined in more detail.

Transforming Technology

‘Technology’, as used in this paper, is not limited to hardware, but also includes software and ‘orgware’. Software comprises the principles, rules and knowledge base for using hardware. Orgware describes the organisational/institutional arrangements that are essential for innovation and dissemination of technologies.

For example, consider the technology for insulating a home. The hardware is very simple, since it has no moving parts. The software includes the knowledge that energy is transferred by three different mechanisms – conduction, convention and radiation – and that each mechanism requires a different type of insulation hardware: bulk insulation (e.g. batts) to reduce conduction; insulating curtains and pelmets to reduce convective heat flow at windows; and reflective foil to reduce radiation. The orgware involves the training, accreditation and monitoring of the installers and their work. The failure of the Australian government’s residential insulation program in 2009–10 was a failure of orgware.

Another dimension of technology is the degree of risk it imposes upon society. With existing technologies and knowledge, high-risk technologies include nuclear energy, carbon capture and storage, and geoengineering. While some R&D into these technologies could be justified, gambling on these technologies, with our only habitable planet as the stake, is not a game that we can play with a high probability of winning. Energy efficiency and renewable energy – provided they have well-designed and implemented hardware, software and orgware – offer the only safe, very low-carbon, energy technologies that are commercially available or on the brink thereof now (Diesendorf 2009). Based on a portfolio of renewable energy technologies at advanced stages of technological development and ignoring technologies still at the research, development and demonstration stages, we can already envisage energy systems based predominantly or even entirely upon renewable energy used efficiently.

A third dimension of technology is scale. What are the advantages and disadvantages of a medium- to large-scale centralised renewable energy system versus a decentralised small-scale system? There is a range of views in the environment movement, but little research of substance. An exception is the study by Sørensen and Meibom (2000) who developed two 100% renewable energy scenarios, one decentralised and one 'centralised', to meet projected global energy demand in 2050. The decentralised renewable scenario explores how far one can go with local residential and commercial systems alone, comprising small-scale solar, wind and fuel cells. This scenario is constrained severely by the fact that renewable energy resources are geographically distributed inequitably over the world.

The 'centralised renewable' scenario is still decentralised in comparison with two other scenarios explored elsewhere by Sørensen: the hypothetical 'clean fossil' and 'safe nuclear' scenarios. While keeping many decentralised energy systems such as residential solar, the 'centralised' renewable scenario places some types of renewable energy system on non-arable land and off-shore, and transmits the energy generated to consumers by transmission lines as electricity or by pipelines (eg, as hydrogen or methanol). Its energy mix comprises energy efficiency, bioenergy from organic residues, wind power (on-shore and off-shore) and solar power (both small-scale and large-scale). No additional hydroelectric power is included in the scenario beyond plant already existing or under construction. In building each scenario, the authors use a geographic information system to assess the extent to which renewable energy resources match energy demand in different regions of the world. In regions where there is a poor match between supply and demand, such as the UK (MacKay 2009), import and export of energy are added.

The results are particularly encouraging for the 'centralised' renewable scenario. There is in total a global oversupply of renewable energy potential and good matches between supply and demand can be achieved in all regions for the projected demand in 2050. Furthermore, food production is not compromised by using biomass *residues* to produce bioenergy. However, Sørensen and Meibom (2000) find that the decentralised renewable scenario has much greater difficulties in matching supply to demand in different regions. It would require a much larger international and intercontinental trade in energy than the centralised renewable scenario, an outcome that appears to contradict one of the original motivations for decentralised energy, local self-sufficiency. Furthermore, on a global scale, the decentralised renewable scenario leaves little room for increase in supply as developing countries increase their demand. For both these reasons, the 'centralised' scenario is potentially more socially just than the decentralised. To deliver social justice in practice, it would be important to reverse the current trend towards the privatisation of large-scale energy supply.

The need for large-scale centralised energy systems can also be seen by considering the amount of roof area available for self-sufficiency in energy at the residential scale. The average annual residential electricity demand in Australia is about 0.8 kilowatts (kW) per household. If this were to be supplied entirely by solar photovoltaic modules, a system with peak power of about 5 kW occupying a roof area of about 34 square metres would be required. Adding another 5 square metres for solar hot water gives a total area of 39 square metres. Even if we assume optimistically that energy efficiency and conservation could cut demand in half, an average of about 20 square metres of roof exposed to direct sunlight would still be required. This would not be available to many houses and almost all apartments. In other words, residential electricity generation could not supply all of a greatly reduced residential electricity demand.

Residential demand is only about one-quarter of total electricity demand. The remaining 75% of electricity is used for industrial and commercial purposes. Granted that part of this demand could be dispensed with, because it is used to manufacture frivolous and unnecessary products, it is clear that centralised electricity generation will be needed for these end-users. We cannot escape the fact that the manufacture of solar hot water systems, solar PV modules, concentrating solar thermal collectors, wind turbines and railways needs raw materials such as steel, aluminium, glass, cement, plastics and rare earth elements, all of which are energy-intensive to produce. These vital technologies also need sophisticated engineering and manufacturing processes to make them work well. They cannot be produced safely or efficiently, in environmental and economic senses, on a cottage scale. Thus large-scale wind, solar, geothermal, wave and other renewable energy sources will be needed and they will have to be connected to one another and to energy users through the electricity network. In an industrialised country like Australia, the dream of a totally self-sufficient household is not available to the vast majority of people.

The alternative of returning to a pre-industrial society is no longer available either. Before colonisation, Australia supported about 0.75 million indigenous people in a gatherer-hunter lifestyle. Since colonisation, Australia's population has increased to 22 million and a large fraction of the land area has been severely damaged by land clearing, soil loss, erosion, dryland salinity, exotic plants and feral animals (Lindenmayer *et al*. 2008). We cannot go back and we cannot continue into the future with business-as-usual either. The real solution is more complex than either of these extremes: to work simultaneously to develop 'green' technologies, an ecologically sustainable and socially just economy, and the end of population growth. Because of the urgency of global climate, prioritising resources among these three areas must be governed by the need to obtain large changes quickly.

In broad terms, the policies needed to implement a sustainable energy system, based on the efficient use of renewable energy, are understood, although there is much debate about the details. The basics are (Diesendorf 2009, ch. 4):

- A steadily increasing carbon price from which most of the revenue is returned to households and to workers disadvantaged by the transition.
- Until the carbon price is sufficiently high, either feed-in tariffs or renewable energy certificates covering all the principal renewable energy technologies and lasting at least 20 years. Thus the design limitations of existing renewable energy policies (Buckman & Diesendorf 2010) are overcome.
- Until the carbon price is sufficiently high, a ban on new conventional coal-fired power stations and major refurbishments of old ones. A similar outcome could be achieved by setting emission standards for new and refurbished power stations at 0.5 tonnes CO_2-e per megawatt-hour of electricity generated.
- Mandatory energy labelling and mandatory energy performance standards for all residential and commercial buildings, not just new ones, and all energy-using appliances and equipment.

- Government funding for research, development and demonstration of low-carbon systems and materials.
- Government funding for essential infrastructure such as new transmission lines and railways.
- Termination of subsidies to the production and use of fossil fuels.
- Regulation to confine the charging of batteries of electric vehicles to renewable energy, either from direct sources or indirect via Green Power (Diesendorf *et al.* 2010).
- Integration of urban planning and transport planning.

All of these policies are necessary; none can be highly effective on its own.

Ending Growth in Per Capita Consumption

Endless growth in consumption per person is not an option on a finite planet. Terminating such growth could be facilitated by encouraging a shift away from the dominant conceptual framework of economic growth, towards the concept of biophysical sustainability. While economic growth is expansion of economic activity, usually measured by an increase in GDP or GNP, biophysical growth is a different concept, namely growth in the use of energy, materials, land and population.

In theory we could have economic growth without biophysical growth, although in practice this rarely happens. Achieving such decoupling is the forlorn hope of ecological modernisation. While studies based on real data indicate that some dematerialisation of the resource-intensive Australian economy could be achieved in theory, this would fall far short of the requirements for meeting the nation's long-term greenhouse target (Schandl & Turner 2009). In practice rapid growth in flows of materials and energy is occurring in the Asia-Pacific region (Schandl *et al*. 2010). Therefore the strategy presented in this paper takes ecological modernisation as necessary but far from sufficient. Instead it puts the principal emphasis on ending biophysical growth. Then economic growth can be recognised as a secondary concept that has received too much emphasis in the past. As long as there is no biophysical growth and all adults who wish to work are employed and receive sufficient income, growth in GDP becomes a redundant side-issue. The focus on limiting biophysical growth enables us to bypass the frequently-asked question of 'Can we stop climate change without economic growth?'.

In Herman Daly's conception, a steady-state economy involves minimising the throughput of materials, energy and people (Daly 1977; 2008). This process could be commenced by the following policies (Daly 1977; Davies 2004; Diesendorf 2009, ch. 4):

- introducing minimum and maximum incomes – minimum incomes recognise the value of work that is currently unpaid, while maximum incomes constrain the accumulation of individual wealth (Daly 1977);
- reducing official working hours (Hayden 1999);
- taxing 'bads' instead of 'goods' (Daly 1977), for instance by introducing a carbon tax;
- reducing speculative trading by introducing a transaction tax on all foreign exchange dealings (Davies 2004);
- putting a brake on speculative lending by increasing the fractional reserve initially to 50% and in the longer term to 100%;
- introducing alternatives to GDP as official indicators of socio-economic performance;
- resisting attempts to strengthen the powers of corporations (*ibid.*);
- strengthening laws and economic instruments to make polluters pay and to increase reuse and recycling of materials.

Since exploration of models for a steady-state economy is still in its infancy, care must be taken that economic reform does not create a failed growth economy, which is not the same as a steady-state economy (Daly 2008). With this caution in mind, the policies listed above were selected from proposals by several authors with the goal of simultaneously improving the present system and facilitating change towards a steady-state system that is more environmentally sound and socially just. The implications of these and other policies still need to be investigated by modelling and brought into constructive public debate.

Ending Population Growth

This issue has both national and global dimensions. Even among environmental and social justice NGOs in Australia, there is strong resistance to discussing the population problem. Among those who only mention it in order to dismiss it as an issue, there is much logical confusion, with throwaway lines such as 'The population argument is both racist and sexist, shifting the responsibility of Australian consumer-citizens on to the backs of women in the global South' (Salleh 2010: 18). This rhetoric bears little relation to the actual population concerns in Australia in 2010, for example as expressed by O'Connor and Lines (2010). Since Australia has the highest per capita greenhouse gas emissions in the OECD, every additional Australian has a higher impact than an additional person almost anywhere else in the world. To make matters worse, Australia's rate of population growth is one of the highest in the OECD. There is nothing racist or sexist about wishing to limit Australia's population growth.

In terms of social justice, many of those who argue for the stabilisation of Australia's population also support an increase in refugee immigration on humanitarian grounds. There is no necessary contradiction between these two goals, since refugees comprise less than 5% of immigration at present. Their intake could be doubled or tripled while ending population growth, provided the much larger category of skilled migration is reduced. This would also address the social justice issue that skilled migration from poor countries into Australia is further impoverishing the countries of origin.

Non-coercive policies for stabilising population are understood, but even quite radical groups and individuals are still avoiding or denying them. In poor countries the solutions involve economic development that tackles poverty and provides security for the aged, provision of contraception and the empowerment and education of women (Bloom & Canning 2008). To assist in achieving these goals, rich countries should increase their overseas aid budgets and keep them separate from their goals of increasing trade. In rich countries population control policies involve removing any incentives for births; reducing immigration rates for all except refugees; and resisting the population boosting pressures and propaganda from the property development and other industries and the Roman Catholic Church.

For a recent debate on the population issue within a broad progressive context, see the articles by Bartlett (2010) and Diesendorf (2010a) in the journal *Overland*.

Political Realities

In Australia neither of the major political parties has effective policies for achieving deep cuts in greenhouse gas emissions (Diesendorf 2009; Crowley 2010; Diesendorf 2010b). Under the Howard government (1996–2007), there was clear evidence from two independent whistleblowers that the government colluded with the big greenhouse gas emitting industries to avoid strong policies to cut emissions and support renewable energy (ABC 2004; Pearse 2007). Under the Rudd-Gillard government (2007–2010), the evidence is substantial but indirect, based on the government's failure to implement its 2007 election promises apart from the symbolic one to ratify the Kyoto Protocol (Diesendorf 2009, ch. 2; Diesendorf 2010b).

The outcome of the 2010 federal election, with a minority Labor government in power with the support of three Independents and the Greens, offers the possibility of small improvements in climate/energy policies, such as the possible introduction of a low carbon price. However, it seems likely that the only pathway to radical change is through substantial growth in the social movement for climate action (Diesendorf 2009; Tattersall 2010). Despite the efforts of the annual Climate Action Summit (see Climate Action Summit, undated), which brings together hundreds of climate action groups, and the national conference of Climate Action Network Australia (see CANA, undated), this movement appears to be fragmented in terms of shared principles and policies.

Conclusion

The transition to an ecologically sustainable, socially just society needs appropriate technology and a steady-state economy and population. For climate mitigation, most of the necessary energy efficiency and renewable energy technologies already exist for achieving zero emissions within the energy sector by 2050. Policies to make such radical changes in Australia's energy system and to stabilise the nation's population are easy to state, but difficult to implement because of opposition by powerful vested interests. Policy proposals are also listed here for commencing the transition towards a steady-state economy, while more research is carried out to develop more powerful policies. A strong social movement is needed to inform the public about the need for change and apply pressure on governments and business to implement effective policies.

To make the transition, we cannot afford to delay the ongoing technological transformation until the other less-advanced goals of steady-state economy and population have been achieved. Climate change is already upon us and is moving rapidly towards irreversibility. We must work on all fronts, while placing the greatest weight on obtaining early successes from technological change. This in turn requires many non-technical policies and programs, in regulations and standards, price structures and taxes, direct government expenditures, education and training, and institutional change (Diesendorf 2009, ch. 4).

In a planet characterised by overpopulation and vast areas of polluted, eroded, compacted and nutrient-deficient land, a sustainable society based primarily on cottage industries is not an option. For energy production in particular, a mix of centralised and decentralised systems, publicly controlled, would work best and be the most equitable. However centralised systems would have to play the major role.

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