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COVID-19 and economic recovery in compliance with climate targets

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Non-technical summary

A small benefit of the disastrous COVID-19 pandemic has been the temporary reduction in greenhouse gas emissions. Therefore, this paper asks: what strategies can return people to work *without* returning to the old high-emissions economy? How can we modify the old economic system to reduce environmental impacts while rebuilding employment? Technological change, such as replacing fossil fuels with renewable energy (RE), is necessary but, in an economy that's growing, unlikely to be sufficiently rapid to avoid dangerous climate change. Degrowth in physical consumption, especially by the 'rich' 10%, towards a steady-state economy, is needed as well as low-carbon jobs.

Technical summary

In planning recovery from the COVID-19 pandemic, most governments aim to return to economic growth that, by default, is closely coupled to growth in consumption of energy, materials and land, together with growth in population in some countries. This scenario almost certainly forecloses the option of a smooth transition to a climate in which global heating is limited to 1.5°C above the pre-industrial level, the aspirational Paris target. Although the transition to energy efficiency and 100% RE – based mainly on wind, solar and hydro – is now technically feasible, affordable and progressing in some countries, states, cities and businesses, technological transformation would be chasing a retreating goal if economic growth returns. Even to stay below 2°C, reducing consumption, especially by the rich 10%, is needed as well as technology change. Therefore, we explore a pandemic recovery scenario in which low-carbon employment creation is fostered during a process of general degrowth, in biophysical terms, towards an ecologically sustainable steady-state economy. Strategies are suggested for governments to create low-carbon jobs, together with reduced consumption, and to drive and finance the transition. With strong public pressure on governments and business, a 2°C target without overshoot may still be possible.

Social media summary

Degrowth can be combined with green employment to cut emissions while improving social equity.

1. Introduction

In the first half of 2020, as a result of the COVID-19 pandemic, global CO_2 emissions were 8.8% lower than in the same period in 2019 (Liu et al., 2020). To limit global heating to the aspirational Paris target of 1.5°C above pre-industrial temperatures (UNFCCC, 2015), global CO_2 emissions would have to be reduced by about 55% by 2030 (UNEP, 2019). This foreshadows the magnitude of the climate mitigation challenge, which is underlined by the observation that, despite the appearance of a second wave of COVID-19 in several parts of the world, there was, commencing in April–May 2020, an increase in global emissions as some economies started to recover from the pandemic (Liu et al., 2020).

Yet, business activity must regrow, in order to provide the desperately needed jobs that were lost, and even selective 'green' growth will increase consumption. This raises the following research questions, which are also questions of urgent practical politics: how can climate change be mitigated while economies recover from the pandemic? More generally, how can pandemic recovery be designed to avoid repeating the adverse environmental and social impacts of the old economic system?

Critiques of the existing economic system, and neoclassical economics theory that allegedly justifies it, abound (e.g. Blatt, 1983; Daly, 1977; Daly & Cobb, 1990; Dennis, 2016; Keen, 2011; Ormerod, 1994; Smith & Max-Neef, 2011; Waring, 1988). These authors argue that the economic system is environmentally destructive because it encourages endless growth in the consumption of energy, materials and land, together with population growth, on a finite planet, and because it doesn't distinguish sufficiently between environmentally beneficial consumption/production on one hand and environmental damaging consumption/production on the other hand. The critique also points out that the old system fosters inequity based on exploitation and other forms of social injustice. Inequity fosters ill-health, reduced life expectancy, illiteracy, violence, crime and other social problems (Wilkinson & Pickett, 2010). The critique of neoclassical macroeconomic theory is that it contains unjustifiable assumptions and fundamental internal contradictions, and so has little relevance to real-world economies.

Therefore, during the pandemic and its recovery, there is the opportunity to debate, develop and implement new or modified socioeconomic systems that can create and maintain 'sustainable prosperity' while being consistent with ecological sustainability and improved social equity/justice (D'Alessandro et al., 2020; Wiedmann et al., 2020). Within this context, the scenario of this paper addresses rapid climate mitigation for the former and full employment, together with health benefits (Krug & Eberl, 2018; WHO, 2018), for the latter.

Energy generation from fossil fuels – providing electricity, non-electrical heat and transportation – was responsible for 73% of global greenhouse gas emissions in 2016 (Ge & Friedrich, 2020). Therefore, the vast majority of fossil fuel resources must be left in the ground (Steffen & Rice, 2015). Mitigation must be rapid because we may have only a few years at most to keep the global average heating below 1.5°C (DNV-GL, 2020; Lenton et al., 2019), taking account of feedbacks. Global energy-related CO_2 emissions increased by 12.7% from 2010 to 2018 (IEA, 2019). Realistically, achieving 1.5°C appears impossible, except as a result of economic collapse, but 2°C may still be achievable, because its carbon emissions budget is about three times that of the 1.5°C target (IPCC, 2018, Table 2.2). Even 2°C requires an urgent break in current emission trends (Friedlingstein et al., 2014).

Section 2 discusses the strengths and limitations of technological change in transitioning rapidly to net zero emissions, focussing on the energy sector. It finds that technological change is necessary, but unlikely to be sufficient for keeping heating significantly below 2°C, and therefore that socioeconomic and behavioural changes may be necessary. Hence this paper considers a COVID-19-recovery scenario with two principal components.

One component, called *low-carbon jobs*, involves creating new employment in labour-intensive work with relatively low-carbon emissions (Section 3.2). This involves both technological and socioeconomic changes. In the energy sector, these jobs are created by substituting renewable energy (RE) for fossil fuels while increasing energy efficiency (EE) and energy conservation. However, even these selective activities will increase consumption to some degree and hence emissions (Suh, 2006). Therefore, the second component of the scenario (Section 3) is *degrowth to a steady-state economy* (Daly, 1977; D'Alisa et al., 2014; Dietz & O'Neill, 2013). The pandemic has assisted to some degree in facilitating degrowth, because many people have become accustomed to working from home and walking and cycling for recreation near their homes. Degrowth requires socioeconomic and behavioural changes.

Section 4 discusses a strategy for degrowth, including policies for reducing rebound and funding the transition using Modern Monetary Theory in countries where it is applicable. Section 5 is the general discussion and conclusion.

2. Technological change is necessary but not sufficient

2.1 Renewable energy and energy efficiency can replace fossil fuels

A large body of evidence – comprising scenario studies, simulations and practical experience in several regions, countries and states/provinces – indicates that zero-emission energy could be provided by a combination of RE and EE and that the transition would be affordable (e.g. Bogdanov et al., 2019; Butler et al., 2020; Diesendorf & Elliston, 2018; Elliston et al., 2016; Graham et al., 2020; IRENA, 2020; Jacobson et al., 2015, 2018; Lazard, 2019; Ram et al., 2019). Furthermore, recent research indicates that the energy return on energy invested of renewable electricity technologies and systems may be typically equal to or greater than that of fossil-fuelled electricity (Brockway et al., 2019; Diesendorf & Wiedmann, 2020; Leccisi et al., 2016; Raugei & Leccisi, 2016).

The main elements of the transition strategy proposed by these and other RE and EE researchers are to:

(1) improve EE of buildings, appliances and industrial processes;
(2) replace fossil fuelled electricity generation with renewable electricity and storage;
(3) electrify non-electrical heating and most transportation;
(4) use renewable electricity to split water to produce hydrogen, convert it to ammonia which is more manageable, and use this 'renewable' fuel in aircraft and ships and for long-distance road transport in remote areas and
(5) assist workers disadvantaged by the transition by retraining, relocation and retirement packages.

Table 1 summarises the status and affordability of the proposed strategic initiatives for the RE + EE scenario.

Most global electricity will be generated by wind and solar supplemented by hydro. Regions lacking these RE resources will import renewable electricity, in most cases by transmission line and in a minority of cases as gaseous or liquid 'renewable' fuels by a tanker ship. Thus, a relatively rapid global transition, completed before 2040, for transitioning to renewable *electricity* and electrifying most transport, appears technically and economically feasible. This covers the majority of emissions in most countries. But, transitioning fossil-fuelled heating, for homes, commercial buildings and industry, to electricity may take longer because of the long lifetimes of existing fossil-fuelled heating technologies (REN21, 2019). Non-energy industrial emissions (e.g. making cement and iron ore), 'green' hydrogen and agriculture still need more research and development.

2.2 Chasing a receding target

From 2010 to 2017, global total final energy consumption (TFEC) grew by 10% (IEA, 2019). Given that the global population growth rate averaged over the same period was 8.5% (United Nations, 2019), TFEC per person grew 1.57% over the same period. Global material flows have also increased (Wiedmann et al., 2015). Thus, apart from the pandemic pause in 2020, technology change has been chasing a receding target. Since actions to slow population growth (education of women, dissemination of contraceptive information and improved social security) are likely to be slow, the principal mitigation efforts must focus on both technological change and reducing energy consumption per person.

Similarly, although technological improvements can make some reductions in emissions from non-energy industrial

Table 1. Status of EE, RE and other low-carbon technologies

Initiative	Technological status	Economic status 2020	Comment
EE improvements in buildings and appliances	Mostly CA	Mostly affordable	Retrofitting some types of existing buildings beyond basic actions can be expensive
RElec, supported by storage and demand management, substituting for FF electricity	CA	Affordable for wind, solar PV, most hydro and demand management	Cost of on-shore wind and solar PV is generally less than from new coal and nuclear energy and soon will be less than *operating* cost of thermal power stations; off-shore wind is competitive with new nuclear
Energy storage	Batteries, hydro and pumped hydro CA; others D	Affordable for hydro; others mostly LA	Utility-scale batteries becoming affordable for frequency control and short-term storage for arbitrage; other non-hydro storage still expensive but costs are declining
Electrify road transport	Mostly CA	Affordable for some fleets	EVs expected to become generally competitive by mid-2020s and dominant mode of transport in 2030s
Air and sea transport	D	Uneconomic at present	Development of more efficient, cheap, 'green' hydrogen and ammonia needed
Electrify heating by FF	CA	Affordable for many technologies	Transition slow while existing, expensive FF heating systems are still operating
Non-energy: industrial, agriculture, forestry and other land-use	Low-carbon versions not well developed yet	Ending logging of native forests is affordable; too early to assess other industries	Cheap hydrogen production needed for steel-making; low-carbon cement not yet CA; dietary changes needed
Assist disadvantaged workers	Barriers are political, not technological	Net cost to governments, but see Section 4	More new jobs can be created in EE and RE than are lost in FF

CA, commercially available; D, demonstration stage; LA, limited affordability; EE, energy efficiency; RElec, renewable electricity; FF, fossil fuel; PV, photovoltaic; EV, electric vehicle.
Sources: Drawn from Jacobson et al. (2015, 2018), European Commission (2019), Ram et al. (2019), REN21 (2019), Butler et al. (2020).

processes and agriculture, reductions in consumption – for example, by increased reuse and recycling of materials and eating less red meat – will also be necessary in these sectors.

3. Socioeconomic and behavioural strategies to reduce consumption

3.1 Choice of strategy

Wiedmann et al. (2020, Table 1) have identified a wide range of strategies for 'sustainable prosperity', ranging from radical approaches such as Eco-socialism and Eco-anarchism, through reformist approaches such as Post-Growth and Steady-State Economies, to Green Growth, such as ecological modernisation characterised partly by economic growth decoupled to some degree from environmental impacts. The scenario of the current paper combines low-carbon jobs, which inevitably drive some growth in economic activity, with a reformist strategy comprising degrowth to a steady-state economy (Daly, 1977; D'Alisa et al., 2014; Dietz & O'Neill, 2013). Low-carbon jobs are necessary, but not sufficient, for cutting emissions (Agora Energiewende, 2020; Parrique et al., 2019).

This strategy is chosen for the following reasons:

(1) to restore employment to people who lost it during the COVID-19 pandemic and, if possible, provide employment for all who wish to work; many of the jobs lost are in the service sectors (especially in retail, small businesses and tourism) which are labour-intensive and, apart from air and road transport, relatively low in carbon emissions;
(2) to achieve rapid, deep climate mitigation;
(3) because some parts of the economy (e.g. RE and EE technologies; public and active transport; environmental protection) must grow, while other parts (e.g. fossil fuel use and native forest logging) must decline and
(4) because, beyond a low threshold, economic growth leads to only slight improvements in well-being (Fanning & O'Neill, 2019).

Although the focus of this paper is on government strategies and policies on the macroeconomic scale, it does not discount the possibility that individual and grassroots community initiatives will greatly expand independently from governments. They can reduce emissions and other environmental impacts, but are limited by existing institutions. For example, communities that wish to grow their own food and create their own microgrids are constrained by land access and regulations favouring electricity utilities, respectively. Therefore, government action, driven by changes in individual and community attitudes and behaviour, is necessary to remove barriers.

The current paper uses Herman Daly's (1977, p. 17) biophysical definition of a steady-state economy: '*an economy with constant stocks of people and artifacts* [sic], *maintained at some desired, sufficient levels by low rates of maintenance "throughput"*'. Using a biophysical definition is important, because a monetary definition in terms of GDP obscures the fact that growth in some businesses and industries results in much lower emissions than growth in other businesses and industries. It is well established that *on average* GDP and biophysical impact are coupled, although there are exceptions observed over short periods of time in specific locations for particular environmental impacts (Haberl et al., 2020; Le Quéré et al., 2019; Parrique et al., 2019). However, in recovering from the COVID-19 pandemic, we are less concerned with the average, than the economic activities that can be grown at the margin. Furthermore, in the present

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context, we are not concerned about the fate of GDP – if an index is really needed, other indices, such as the Index of Sustainable Economic Welfare (Lawn, 2006), would be more appropriate.

3.2 Low-carbon jobs

Table 2 compiles suggestions from numerous scholarly, NGO and media publications, for low-carbon employment, that also address major environmental, social and health (WHO, 2018) issues, for which there is generally believed to be medium and high job creation potential. It includes the restoration of low-carbon, high-labour intensity jobs lost during the pandemic. Climate change is a causative factor in many of the issues with high environmental impacts. The high additional employment potential of RE and EE is well documented (Briggs et al., 2020; Hondo & Moriizumi, 2017; IRENA, 2019); employment is also likely to be high for child care, nursing, education and training, and firefighting. Expanding nursing and childcare has both general social and health benefits and specific value as a precautionary approach for managing pandemics, present and future. Firefighting is part of the defence against one of the devastating impacts of climate change (Mullins et al., 2020).

The largest *initial* increases in emissions from employment listed in Table 2 are likely to come from responses involving improvement of physical infrastructure. However some of these investments can lead to net reductions in emissions over their lifetimes: for example, railways that substitute for road and air travel; transmission lines that enable a higher penetration of RE into the grid; energy efficient public/social housing located close to public transport and town centres; pollution control measures that improve public health and hence reduce the demand for medical and hospital facilities. Technological improvements, such as low-emission cement and zero-emission processes for replacing metallurgical coal for making iron, would greatly reduce the emissions from constructing infrastructure. However, selective growth, even in the service sector, is unlikely to reverse the absolute growth in the total biophysical economy (Parrique et al., 2019; Suh, 2006; Victor, 2012). Further reduction of throughput of materials, energy and land-use, together with a levelling off of population growth, is also required.

Although many environmental NGOs are currently recommending Green Growth recovery from the COVID-19 pandemic, very few governments are planning for it. Indeed, the government of Australia, the world's largest exporter of natural gas and one of the two largest coal exporters, has announced a 'gas-led recovery' (Morton, 2020) and budgeted a subsidy to an old existing coal-fired power station (Joshi, 2020). The main barriers to transitioning to low-carbon businesses and industries are vested interests, especially fossil fuel interests (Pearse, 2007). Possibly the best of the inadequate responses is that of the European Commission (2020), which proposed in May 2020 a dedicated recovery budget for 2021–2024 of 750 billion EUR for stimulating the economy and accelerating climate action as part of its European Green Deal and climate objectives. But Agora Energiewende (2020) has questioned whether much of this amount will actually be used for green investment.

4. Strategy for degrowth to a steady-state economy

Media and anecdotal experience indicate that the pandemic, which has resulted in many people staying at home, has led to increased work in home and garden improvements, including EE, rooftop solar and local food production in developed countries that are not subject to total lockdown. Hardware stores, plant nurseries and online stores are booming. This could be fostering some cultural change that can be built on for low-carbon socio-economic recovery. A negative aspect, in terms of emissions reduction, has been the reduction in use of public transport.

Next, a common objection to the effectiveness of saving energy must be addressed.

4.1 Reducing rebound from saving energy

Energy consumption per person can be reduced by EE and energy conservation (Creutzig et al., 2018). *Energy efficiency* is defined as obtaining the same energy service – for example, warm house in winter; hot shower; cold food; mobility – with a reduced energy use. It is achieved mostly by improved technologies, for example, home insulation; water-efficient shower head; energy-efficient refrigerator; efficient vehicle or public transport. *Energy conservation* (sometimes called *energy sufficiency*) is defined as reducing energy use by accepting a modified or different energy service – for example, wearing warmer clothes and accepting reduced home heating in winter; taking a shorter shower; walking or cycling to the local shops instead of driving. Since energy conservation is mostly behavioural, it cannot be legislated directly; it can be facilitated by fostering a culture in which the benefits of sufficiency are contrasted with the downsides of waste. Governments can also provide appropriate infrastructure (e.g. pedestrian areas, cycleways and public transport) to give people alternatives to high-energy activities such as driving cars. Both EE and energy conservation can be implemented quickly and save money as well as energy and emissions.

Saving money by saving energy will lead to some rebound in economic activity, because part of the money saved is inevitably spent or invested in increasing energy use or in consumption in other economic sectors (Binswanger, 2001; Herring & Sorrell, 2009; Sorrell et al., 2020). For example, insulating one's home can result in heating the whole house in winter instead of just the room occupied at a given time. Since wind and solar electricity is now cheaper than from fossil fuels over most of the world (Graham et al., 2020; IRENA, 2020; Lazard, 2019), the implementation of these RE technologies can also lead to some rebound.

Much of the literature on the rebound effect is written within the framework of neoliberal economics, implying that the demand for energy services will never be satisfied (e.g. most chapters in Herring and Sorrell (2009)), that attempting to gain significant reductions in energy consumption is futile and that any rebound from EE should be accepted or even encouraged. This is made explicit by the recent trend to replace the term 'energy efficiency' by 'energy productivity', defined at the macroeconomic level as GDP divided by energy consumption. Thus, although growing energy productivity, absolute energy consumption can increase, as long as GDP grows more rapidly.

Considering the importance of rebound for degrowth economic scenarios, very little research has been conducted on the effectiveness of various policies for reducing it (Font Vivanco et al., 2016). Since economic savings in the energy sector can lead to more expenditure in other sectors (indirect rebound effect), policies must extend beyond the energy sector. To follow a scenario of degrowth, reducing consumption is necessary, especially in developed and rapidly developing countries (see below). Policy options include (Font Vivanco et al., 2016; Nørgaard, 2008):

(1) mandatory labelling, regulations and standards for EE of buildings, appliances, equipment and industrial processes;

Table 2. Employment potential of addressing environmental, social and issues

Environmental, social or health issue	Response strategy	Environmental, social or health benefit	Additional employment potential
Climate change + air pollution	EE targets + policies to achieve them by regulations and standards, audits and retrofits	High	High
	RE targets + policies to achieve them, including finance, transmission infrastructure, storage, reverse auctions with contracts-for-difference for utility-scale, fair feed-in tariffs for rooftop solar and market rule changes	High	High
	Fostering of strategic businesses and local manufacturing industries: e.g. insulation; 'smart' electronics; virtual power plants; waste reuse and recycling; components of wind turbines	Medium	Medium
	Infrastructure for public and active transport and electric vehicles	High	Medium
Climate change + over-consumption of freshwater	Priority closure of freshwater-cooled coal-fired power stations that evaporate the water	Medium	Job losses in coal offset by increased jobs in EE and RE
Climate change + over-consumption of groundwater	Ban fracking (hydraulic fracturing) of shale for gas and oil	High	Job losses in fracking offset by increased jobs in EE and RE
Land degradation + biodiversity loss + climate change from agriculture and forestry	Revegetation with native plants; regenerative agriculture; creation and maintenance of national parks	High	High
Biodiversity loss in oceans	Creation and maintenance of marine national parks	High	Medium
Limits to food production	Regenerative agriculture; synthetic vegan food	High	Medium
Shortage of child care staff	Subsidise staff	High	High
Improve public school education	Recruit more teachers and increase their salaries	High	High
Shortage of nurses	Fund nursing training and subsidise nurses' salaries	High	High
Improve academic knowledge and technical skills	Increase government funding to universities and technical/trade colleges	High	Medium
Commodification of access to land	Fund public/social housing and allotments	High	High
Homelessness	Expand public/social housing	High	High
Firefighting	Early detection; expansion of ground and aerial firefighting force; improved land management	High	Medium
Restoration of jobs lost during pandemic in retail, small businesses and tourism		High social and health benefit; low to medium environmental	High

EE, energy efficiency; RE, renewable energy.
Source: Author's selection from many articles.

(2) mandatory labelling, regulations and standards for increased durability of products;
(3) incentives to shift from private to public transport (Turner et al., 2016);
(4) carbon pricing (Sorrell et al., 2020) and, more generally, environmental taxes and
(5) in developed countries, mandating a shorter working week, with salaries/wages reduced proportionately, together with minimum hourly income.

4.2 Jobs growth plus degrowth: curbing the big emitters

Additional policy measures arise from recognising that the vast majority of environmental impacts, including carbon emissions, come from consumption by a small fraction of the world's population (Wiedmann et al., 2020 and references therein). Specifically, the world's top 10% of income earners are responsible for about 45% of global emissions, while the bottom 50% emitters contribute 13% of global emissions (Chancel & Piketty, 2015). The world's rich include high-income earners in both developed and rapidly developing countries. Their environmental impacts come indirectly from their savings and investments (Druckman et al., 2011) as well as their direct expenditure on consumption. Their consumption can be reduced by progressive taxation that discourages very high incomes and by carbon pricing.

The COVID-19 pandemic shows that shutting down economic activity and doing nothing else results in widespread unemployment and impoverishment. However, modelling of the biophysical economy of Australia (Turner, 2016, 2019) shows that employment can be maintained while GDP and biophysical throughput are reduced during transition to a 'sustainable future', *provided* additional policies and behavioural changes are implemented. These measures include reducing household consumption, reducing the length of the working week and stabilising the population. Macroeconomic modelling of the Canadian economy obtains similar results for its scenario of degrowth to a steady-state economy (Victor, 2012, 2019; Victor & Rosenbluth, 2007), which Victor defines in terms of GDP and GDP per capita. Based on macrosimulation modelling, D'Alessandro et al. (2020) argue that degrowth – together with a job guarantee, working time reduction and a wealth tax – is an economically and politically feasible scenario for cutting emissions and improving social equity. However, the barriers to degrowth are vested interests, neoliberal economics and the pro-growth institutions and culture they have created that lock people in developed countries into high consumption energy-intensive lifestyles (Alexander, 2012).

To the author's knowledge, the only environmental NGOs supporting a steady-state economy or degrowth are those specifically dedicated to those purposes. Although degrowth has been ignored or dismissed as preposterous by almost all governments and trade unions, government interventions in the economy in response to the pandemic have set aside neoliberal dogmas against subsidising businesses, increasing (temporarily) unemployment and social security benefits, and avoiding huge deficits. For example, the Australian government has allocated a total of AUD 206 billion to COVID management and recovery in 2019–20 and 2020–21, compared with its revenue in 2019–20 of AUD 470 billion and estimated revenue in 2020–21 of AUD 464 billion (Australian Government, 2020). Governments have been forced to recognise implicitly that market economics has failed to manage the economic impacts of the pandemic. This opens up the opportunity for public questioning of the validity of neoliberal economics, including the notion that eternal growth on a finite planet is possible and desirable.

The remaining question is how governments can fund the transition to a steady-state economy with low throughput.

4.3 Funding the transition

4.3.1 Funding in conventional macroeconomics

Within the framework of conventional macroeconomics, a government can use the following policies: increasing taxation, reducing other expenditures such as social security and education, and borrowing, for example, by issuing government bonds. The first is often unpopular with the electorate, the second tends to increase poverty and the third gives concerns about government debt, high expenditure on interest and a burden on future generations. Some specific policies for increasing government revenue and reducing wasteful expenditures, that are unlikely to damage social equity, are (Grudnoff & Richardson, 2018):

(1) ensuring that multinational corporations selling goods and services in the country of interest are taxed adequately;
(2) removing any arbitrary legislative caps on the tax to GDP ratio;
(3) cancelling any proposed tax cuts;
(4) removing government incentives for citizens to speculate in property;
(5) reducing superannuation tax concessions;
(6) placing super-profit taxes on the mining industry and
(7) introducing a financial transactions tax.

Additional economic savings can be obtained from the reduction in air and water pollution and their health impacts, as well as the reduction in water use and land degradation associated with many coal-fired power stations.

4.3.2 Funding in Modern Monetary Theory

In recovering from the Global Financial Crisis and during the present COVID-19 crisis, the US government has been 'printing' (i.e. creating digitally) trillions of dollars and using it to buy bonds, without causing inflation (Holland et al., 2020). This supports unintentionally the broad approach to macroeconomics of Modern Monetary Theory (MMT) (Kelton, 2020; Mitchell et al., 2019),[i] which argues that sovereign states that issue their own fiat currencies[ii] are not like households in being constrained to spend only their revenue. Instead, they can create debt-free money, so long as they manage their currency so that it retains its value. If governments spend beyond the capacity of their economy to produce, then, and only then, inflation becomes a risk. However, economies depressed by the pandemic are operating well below capacity. MMT builds on Keynesian economics, the concept of 'functional finance' introduced by Lerner (1943), and the insights of Mosler (2013).

Within the framework of MMT, the debt-free process by which governments can create money, sometimes called Overt Monetary Financing, is as follows (Mitchell, 2015, p. 364):

> …governments typically spend by drawing on a bank account they have with the central bank. An instruction is sent to the central bank from the treasury to transfer some funds out of this account into an account in the private sector, which is held by the recipient of the spending. A similar operation might occur when a government cheque is posted to a private citizen who then deposits the cheque with their bank. That bank seeks the funds from the central bank, which writes down the government's account, and the private bank writes up the private citizen's account. All these transactions are done electronically through computer systems.

MMT proponents recommend that relevant governments – which include the USA, Canada, UK, Japan and Australia – establish a permanent Job Guarantee programme (Kelton, 2020; Mitchell et al., 2019). People who would be otherwise unemployed would be paid the minimum wage by the national government for working in positions established by all tiers of government and non-profit organisations. The Job Guarantee would stabilise the economy by employing more people during downturns, maintaining or enhancing skills until the economy recovers, and employing fewer people during boom times. Because wages would be generally less than those paid by the private sector, these new jobs would not compete significantly with existing jobs, and workers in the guaranteed jobs would still have an incentive to seek higher-paid jobs in the private and public sectors (Kelton, 2020; Mitchell et al., 2019).

Alexander and Baumann (2020) observe that low-income earners, who could practise voluntary simplicity and so participate in degrowth to a steady-state economy, are 'locked in to a very long market commitment in order to buy or rent housing'. They propose that, as well as providing unemployed people with a modest living wage, the government should allow them to rent public land and public housing at 25% of their income.

Governments of countries that do not have sovereignty over their currencies, such as members of the European Union, cannot easily create money and so may be limited at present to the conventional economic measures listed in Section 4.3.1. However, the EU could resolve this by changing Article 123 of the Maastricht Treaty to allow Overt Monetary Financing to be used on an ongoing basis (Mitchell, 2015, p. 367).

5. Conclusion

The COVID-19 pandemic has opened up the opportunity for a sustainable development recovery. This paper proposes a sustainable development scenario that brings together key environmental and social equity aspects, namely climate mitigation and job restoration and creation. If we return to pre-COVID economic growth rates and if mitigation methods are limited to technological change, it will be very difficult to keep the global average temperature increase above pre-industrial temperatures to 2°C by 2050. It is now almost certainly too late for human civilisation to transition smoothly and without overshoot to an increase of 1.5°C. Therefore, in our scenario, socio-economies follow a path of degrowth to a steady-state economy while full employment is ensured by means of a Job Guarantee focussed on low-carbon jobs.

Degrowth is necessary, because even the low-carbon jobs listed in Table 2 will result in increased economic activity and hence an increase in emissions. Indeed, increased economic activity in some sectors is essential for post-COVID-19 recovery. The dilemma can be resolved provided the increase in emissions from low-carbon jobs is more than offset by degrowth in the economy at large. This entails rapidly reducing consumption per person and gradually ending population growth. Degrowth can be focussed by recognising that the rich 10% of human population, who comprise a large fraction of developed country inhabitants and a small fraction of developing country inhabitants, are responsible for the majority of environmental impacts within the existing economic system. Policies to address this situation include progressive taxation to discourage very high incomes, environmental tax reform including carbon taxes, inheritance taxes, a shorter working week and fair minimum incomes.

Realistically, a mass movement is needed to force governments to act against the interests of powerful vested interests and the ideology of endless economic growth which has been embedded in our culture. However, the situation that governments have had to set aside neoliberal economic ideologies during the pandemic makes socioeconomic change less difficult.

It is even easier for governments to foster low-carbon jobs. They must use strategic planning and incentives/disincentives to encourage appropriate businesses and industries. Many state/provincial and city governments, and several national governments, are already implementing such policies, although not rapidly enough. In particular, policies are needed to accelerate EE and conservation, to provide the infrastructure for renewable electricity, to shift heating from fossil fuels to electricity, and to foster public transport, active transport and electric vehicles. Environmental tax reform and a shorter working week would help drive this component of the strategy.

A Job Guarantee can be paid at the minimum wage by national governments. Labour-intensive jobs can be created by all levels of government and non-profit organisations mainly in the areas of caring for people and caring for the environment. Although national governments could fund the Job Guarantee temporarily by borrowing while interest rates are low during COVID recovery, a permanent solution for countries that have monetary sovereignty and are operating below full economic capacity is to create money as justified by MMT. Renting public land to low-income earners could also contribute to the transition while improving social equity.

With strong public pressure on governments and business, led by environmental, social justice and economic reform NGOs, transition to a 2°C target with full employment may still be possible.

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Ethical standards. This research and article comply with publishing ethics guidelines of *Global Sustainability*.

Notes

[i] For a short popular account, see Hutchens (2020).
[ii] Government-issued currency that is not backed by a physical commodity such as gold, but rather by the government that issued it.

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