Reduced work hours as a means of slowing climate change

David Rosnick[1] [Center for Economic and Policy Research, USA]

Abstract
The choice between fewer work hours versus increased consumption has significant implications for the rate of climate change. A number of studies (e.g. Knight et al. 2012, Rosnick and Weisbrot 2006) have found that shorter work hours are associated with lower greenhouse gas emissions and therefore less global climate change. This paper estimates the impact on climate change of reducing work hours over the rest of the century by an annual average of 0.5 percent. It finds that such a change in work hours would eliminate about one-quarter to one-half of the global warming that is not already locked in (i.e. warming that would be caused by 1990 levels of greenhouse gas concentrations already in the atmosphere). The analysis uses four "illustrative scenarios" from the Intergovernmental Panel on Climate Change (IPCC), and software from the Model for the Assessment of Greenhouse-gas Induced Climate Change to estimate the impact of a reduction in work hours.

Introduction

The world will have to cope with some amount of climate change. Already, humans have released sufficient greenhouse gases into the atmosphere to raise the average surface temperature of the planet. Atmospheric concentrations will be high enough as to induce further warming for some time—even if emissions of greenhouse gases return to 1990 levels.

Heading off more serious climate change will require a variety of policy changes. In this paper, we produce some rough estimates for the impact on the climate due to one possible important policy change—a gradual reduction in work hours. The direct cost of a reduction in work hours is at worst very small. In standard neoclassical models, the loss of consumption due to working less is offset in large part by an increase in leisure. In fact, a reduction in work hours may increase hourly productivity or (when employment is depressed) increase the employed share of the population.[2] These effects may offset aggregate income losses, with higher levels of employment having the additional effect of lowering the cost of unemployment benefits.

To the extent that working less will result in lower production, however, lower production should result in a fall in emission of greenhouse gases. In addition, there may be a shift in emission intensity per dollar of output as consumption patterns change.[3] How all these different factors might interact to change projected emissions is still an open question. Further, the sensitivity of the climate to greenhouse gas emissions is subject to a wide range of uncertainty. Nevertheless, in this paper we will estimate some general rules of thumb for the climate impact of a reduction in work hours. These will depend on the emissions baseline and the response of various actors to the policy change, but are robust to varying estimates of climate sensitivity.

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[2] See Baker (2009) and Baker (2011).
[3] For more in this topic, see Schor (2010).

Climate baselines

To investigate the range of possibilities, we start with the four "illustrative scenarios"[4] from the Intergovernmental Panel on Climate Change (IPCC). The IPCC chose each scenario to represent a particular "storyline" describing alternative evolutions of the world economy. *Very* roughly speaking, the "A1" and "B1" storylines involve low population growth but rapid increases in output, while the "A2" and "B2" storylines assume higher population growth and lower levels of output.

TABLE 1
Storyline quantifiers in 2100

	Population (Billions)	GDP (Trillions of 1990 USD)	Implied GDP per-capita (Thousands of 1990 USD)
A1	7	550	78.6
A2	15	250	16.7
B1	7	350	50.0
B2	10	250	25.0

Source: IPCC, and author's calculations.

These storylines produce a wide range of incomes on a per-capita basis. In part, this is due to differences in assumed productivity growth, but much of this difference reflects variations in population growth within the developing world. For example, if population growth is much faster in developing countries than it is in developed countries, then the worldwide growth in average income per person will be slower than otherwise.

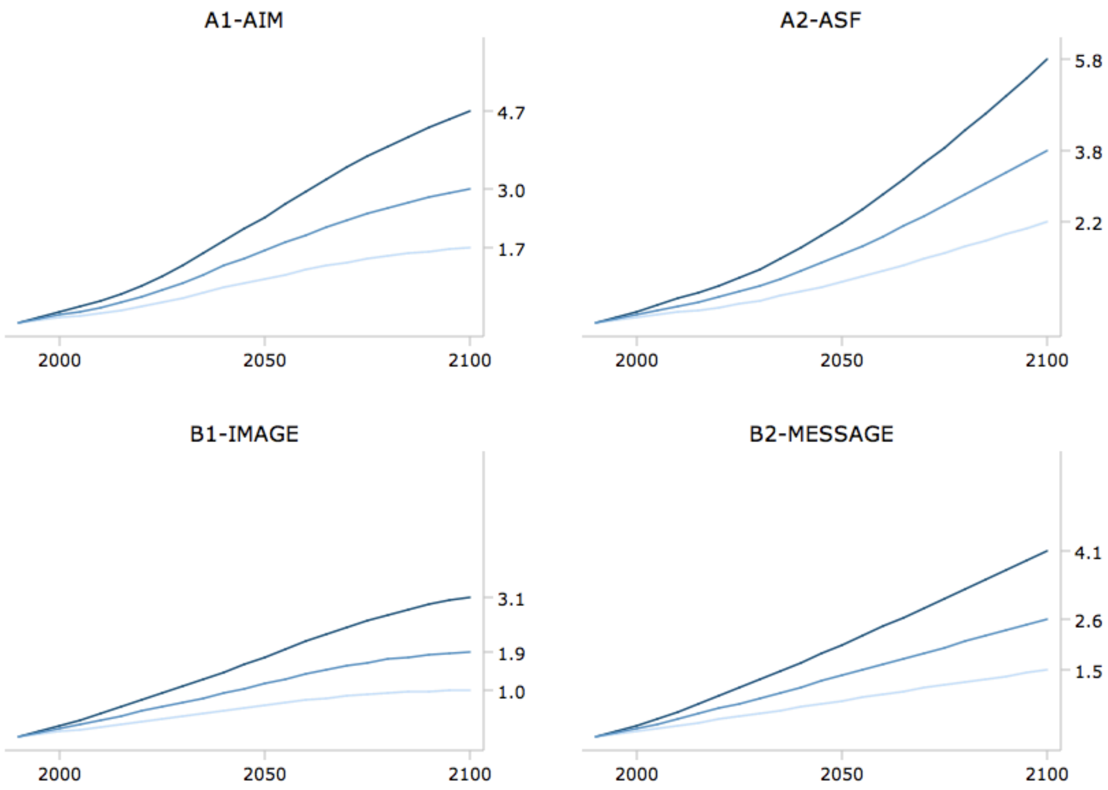
For each storyline, the IPCC chose an illustrative "marker" scenario—a quantitative realization of the storyline produced by one of the several emissions models employed in the report. For example, the marker for the A1 storyline uses the Asian Pacific Integrated Model (AIM) so we call this scenario A1-AIM. Each one of these "marker" scenarios corresponds to a different level of baseline emissions, and a range of possible impacts on climate – depending of the temperature response to the emissions.

We may estimate the baseline climate impact from the emissions associated with each of these four "marker" scenarios by use of the Model for the Assessment of Greenhouse-gas Induced Climate Change (MAGICC) produced by the University Corporation for Atmospheric Research (UCAR). **Figure 1** shows a wide range of possible temperature responses to each scenario.[5] Across the four scenarios, central estimates of warming through 2100 range from

[4] Intergovernmental Panel on Climate Change (2000). Table 4-1, page 175.
[5] MAGICC reports results using a central estimate of 3ºC increase in temperature per doubling of CO2 in the atmosphere. The employed range for this *climate sensitivity* is reported as 1.5-6.0ºC per doubling, which is somewhat broader than the 2.0-4.5ºC reported in the IPCC's *Climate Change 2007: Synthesis Report.*. Though use of MAGICC's default range of results may exaggerate the uncertainty in climactic response, this does not impact the final results of this paper.

1.9ºC (B1) to 3.8ºC (A2). The A2 and B2 scenarios suggest considerable ongoing warming even beyond 2100.[6]

FIGURE 1
Estimated change in temperature (ºC) since 1990—illustrative scenarios

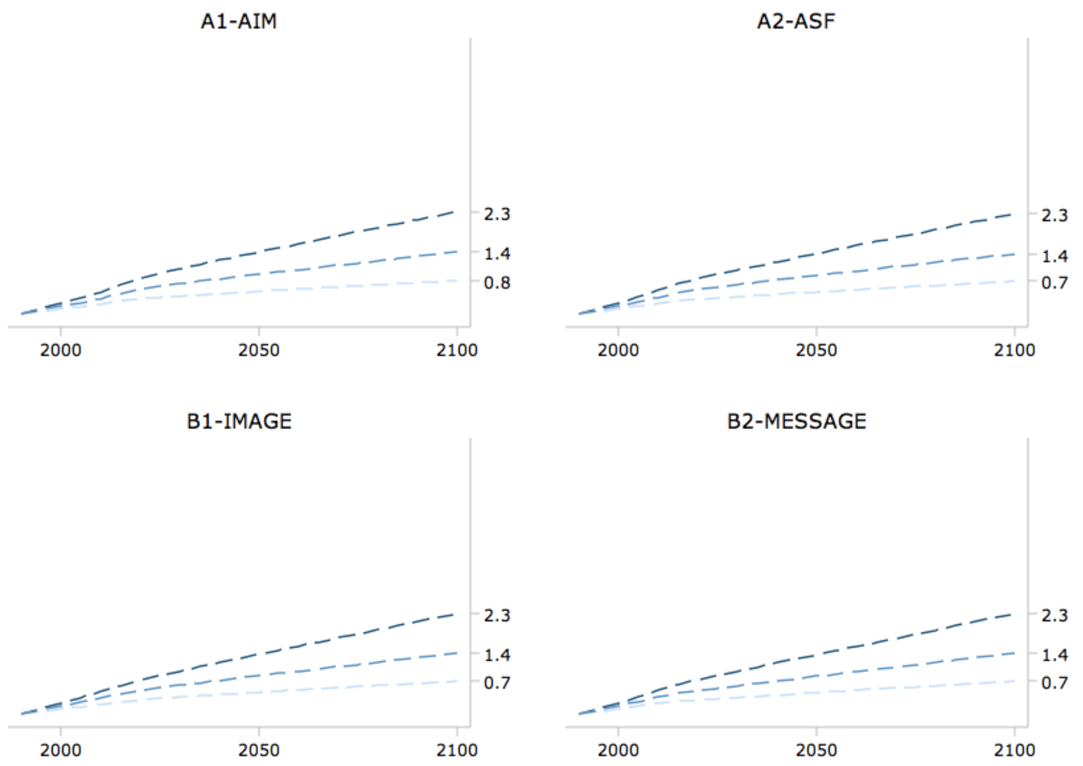


Source: IPCC and author's calculations.

It is important to note that much of this warming is effectively locked-in. In Figure 2, we assume that by 2020 emissions return to and remain at 1990 levels.[7] Because emissions between 2020 and 2100 are identical in each alternative, the results are very similar. Irrespective of policy there will be very likely a minimum of 0.75-2.34ºC of warming--depending on climate sensitivity.

[6] Note that projected climate change is more severe in the A2-ASF scenario than, say, the B1-IMAGE even though GDP is larger in the B1 storyline than A2. Among the storylines, there is considerable variation in the amount of energy or emissions required to produce each dollar of GDP. See IPCC (2000), Chapter 4.4.2.1. A1 Scenarios.
[7] Not all emissions may be input into the MAGICC software—in particular those controlled by the Montreal Protocol. (See Appendix 1 of the MAGICC user manual, available at http://www.cgd.ucar.edu/cas/wigley/magicc/UserMan5.3.v2.pdf) Thus, emissions of CF4, C2F6, and input HFCs are assumed to change relative to baseline in proportion to changes in emissions of SF6 relative to SF6 baseline.

FIGURE 2
Change in temperature (ºC) since 1990 with return to 1990 emissions by 2020



Source: IPCC and author's calculations.

This leaves 0.3-3.5ºC of warming that may be addressed— absent policy measures that would bring us below 1990 emissions levels. If we live in a world with low climate sensitivity to emissions, then we are very fortunate. A B1 future with "a high level of environmental and social consciousness combined with a globally coherent approach to a more sustainable development"[8] would result in very little additional warming. On the other hand if climate sensitivity is high, an A2 future[9] where economic growth is "uneven" with "less international cooperation" and "slower technological change," then we would require considerable action to prevent significant warming.

The IPCC calls "dematerialization" a priority of the B1 storyline—increased consumption of services and improvements in quality rather than simply increasing the quantity of consumption. But increased leisure is a viable alternative as well. As productivity increases, different societies may simply choose to work less rather than fully increase output.[10] In this sense, a B1 storyline could reflect a world with fewer work hours per person—at least relative to alternative futures. In this paper, we ask how climate responds to introducing leisure as a priority into different storylines.

It is worth noting that the pursuit of reduced work hours as a policy alternative would be much more difficult in an economy where inequality is high and/or growing. In the United States, for

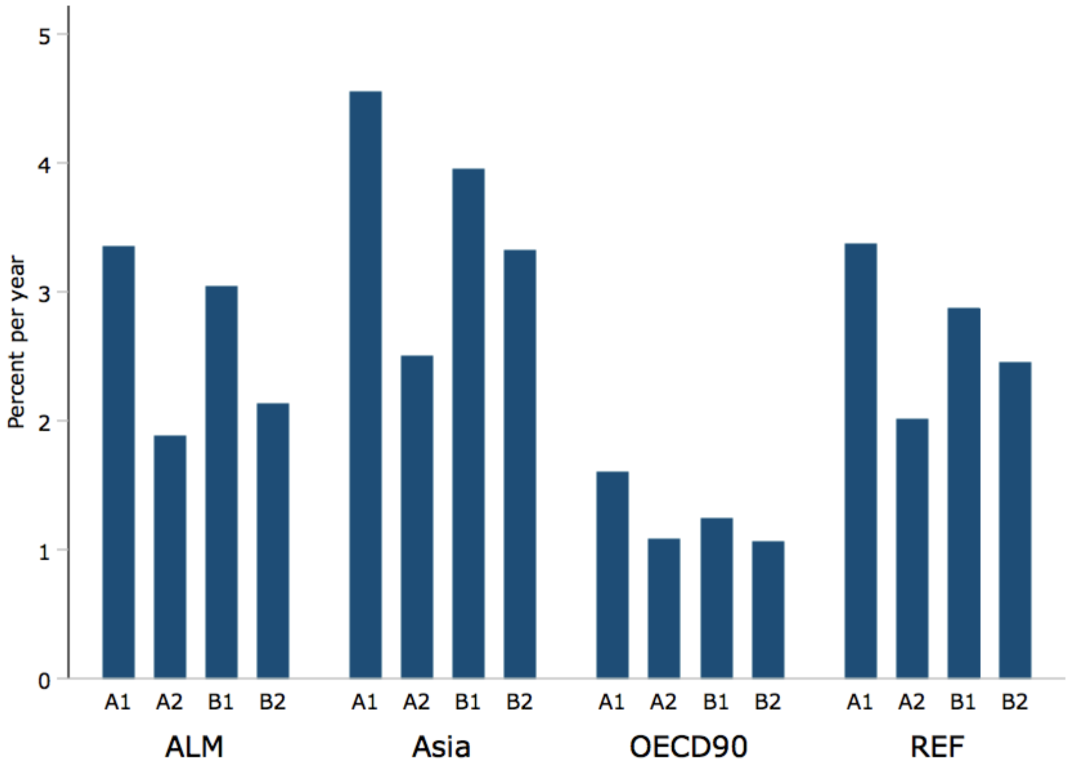
[8] Intergovernmental Panel on Climate Change (2000), Chapter 4.3.3.
[9] Intergovernmental Panel on Climate Change (2000), Chapter 4.3.2.
[10] European workers, for example, are generally as productive as those in the United States; yet they work significantly fewer hours than do their American counterparts. See Rosnick and Weisbrot (2006).

example, just shy of two-thirds of all income gains from 1973–2007 went to the top 1 percent of households.[11] In this type of economy, the majority of workers would have to take an absolute reduction in their living standards in order to work less. The analysis in this paper assumes that the gains from productivity growth will be more broadly shared in the future, as they have been in the past.

Modeling a reduction in work hours

The illustrative scenarios above assume world per-capita income growth of between 1.3 and 2.7 percent per year over the 110-year period from 1990-2100. Some of this income growth reflects greater productivity—the ability of a laborer to produce more in an hour of work. Likewise, some of this income growth reflects additional hours of work performed by the average person. These two may interact in complex ways. For example, an increase in productivity may make it more profitable for firms to increase worker hours, yet the increase in hours may exhaust workers and make them less productive. Similarly, an increase in productivity may raise the wages of workers and allow them to both reduce their hours and raise their incomes, yet these well-rested workers may be even more productive. **Figure 3** shows the projected growth in per-capita incomes by region.[12]

FIGURE 3
Average income growth by region 1990-2100



Source: IPCC and author's calculations.

[11] Piketty and Saez (2003).
[12] These regions are defined by the IPCC. ALM=Africa and Latin America, Asia=Developing Asia, OECD90=OECD countries in 1990, REF=Countries undergoing market reform

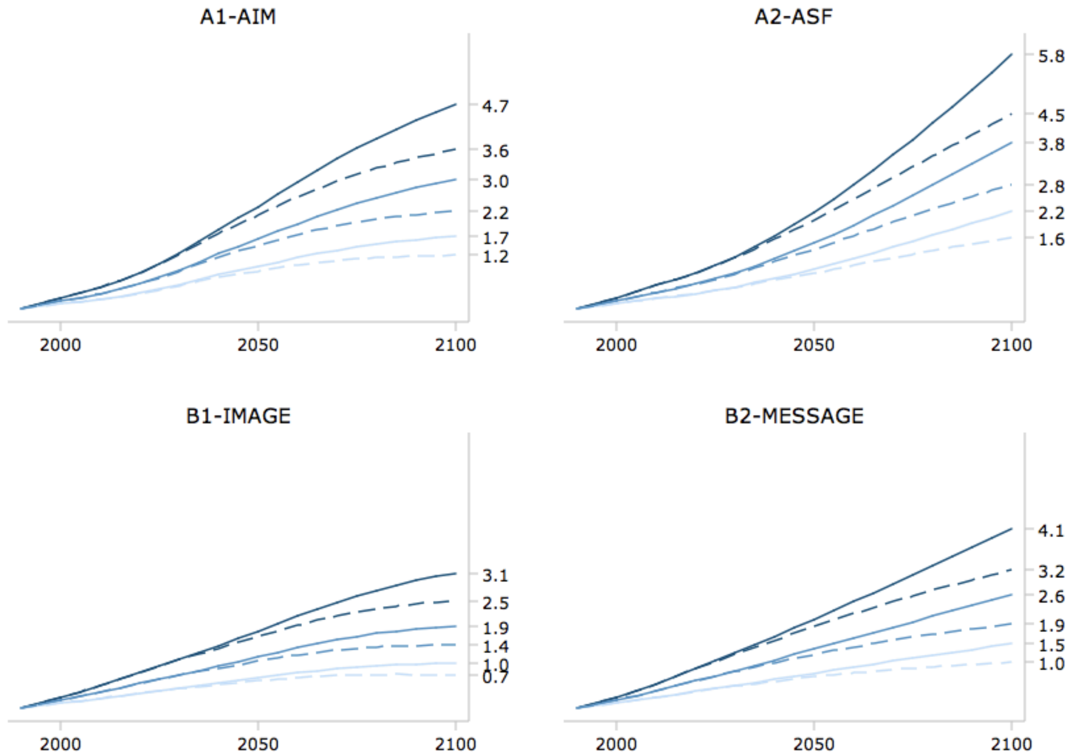
Among developing regions, incomes grow between 1.9 percent and 4.6 percent per year, depending in large part on the scenario. Average incomes in the OECD are projected to grow much more slowly.

Rather than tease out how hours and productivity are determined in these scenarios, let us arbitrarily assert that these projections assume that the developing world converges to the work habits of those in the United States. If, alternatively, the world were to follow a more European model of work, we would expect fewer hours, less output, and lower emissions of greenhouse gases. Specifically, assume that after any interaction with productivity or employment, hours eventually fall by 0.5 percent per year relative to each baseline—starting in 2013.[13]

For developing countries, this amounts to trading in one-tenth to one-quarter of baseline income gains for increased leisure. For the moment, let us also assume that the effect on emissions is disproportionately large in comparison to the fall in hours.[14] Recent work estimated that a 1 percent increase in annual hours worked per employee is associated with a 1.5 percent increase in carbon footprint.[15] We therefore begin with the assumption that every percentage point fall in initial hours leads to a 1.5 percent fall in greenhouse gas emissions.[16] Within the OECD, we will assume only half this effect, reflecting that only the United States would be adjusting to the rest of the developed world. **Figure 4** expands on Figure 1 above by including the corresponding alternative emissions scenarios (shown by the dotted lines).

[13] By 2100, average hours would have fallen by 36 percent. Based on a 40-hour-per-week, 50-week baseline work year, this could be achieved by moving, gradually over 87 years, to a 30-hour week with seven additional weeks of vacation.
[14] Knight, *et. al.* (2012).
[15] Carbon footprint reflects emissions as calculated on a consumption basis. See Knight et al.(2012).
[16] In these scenarios, emissions of CF4 and C2F6, as well as input HFCs are assumed to change in correspondence to emissions of SF6.

FIGURE 4
Estimated change in temperature (ºC) since 1990—baselines and reduced hours—large emissions response



Source: IPCC and author's calculations.

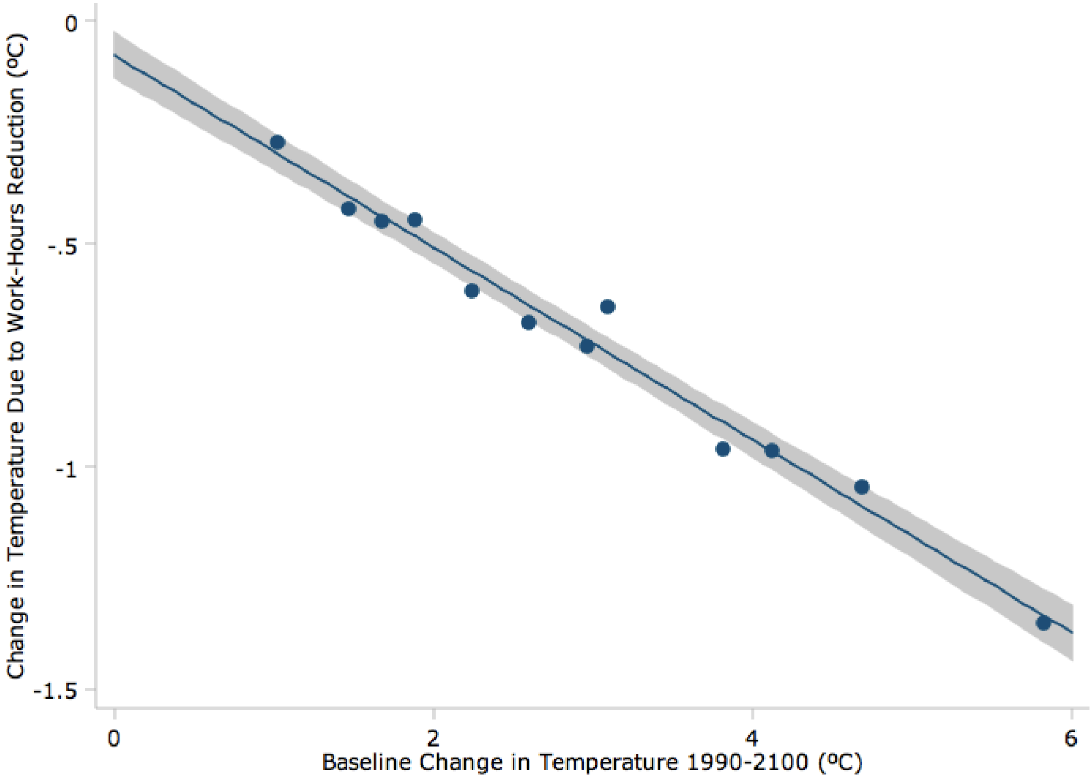
The results vary with the scenario and climate sensitivity to emissions. As we see in Figure 4, work-hours reduction could prevent 1.3 of the 5.8 degrees of average warming projected in the high-sensitivity A2-ASF scenario. On the other hand, work-hours reduction may prevent only 0.3 degrees of the 1.0-degree warming in the low-sensitivity B1-IMAGE scenario.

Figure 5 shows that the greater the baseline increase in temperature, the greater the potential for reduction. It appears that approximately one-fifth of projected warming is countered by the hours-induced reduction in emissions.

Note that this result applies over the wide range of possible climate sensitivities. This allows us to conclude that with 40-70 percent of warming already locked in, between 35-70 percent of addressable warming is avoided by reducing hours in this manner.

Now, let us suppose the emissions response to a change in hours is proportionate, so that a 1 percent reduction in hours associates with a 1 percent reduction in emissions. Obviously, this reduces the impact on climate change, as seen in **Figure 6**.

FIGURE 5
Baseline climate change and mitigation by 2100—large emissions response to hours



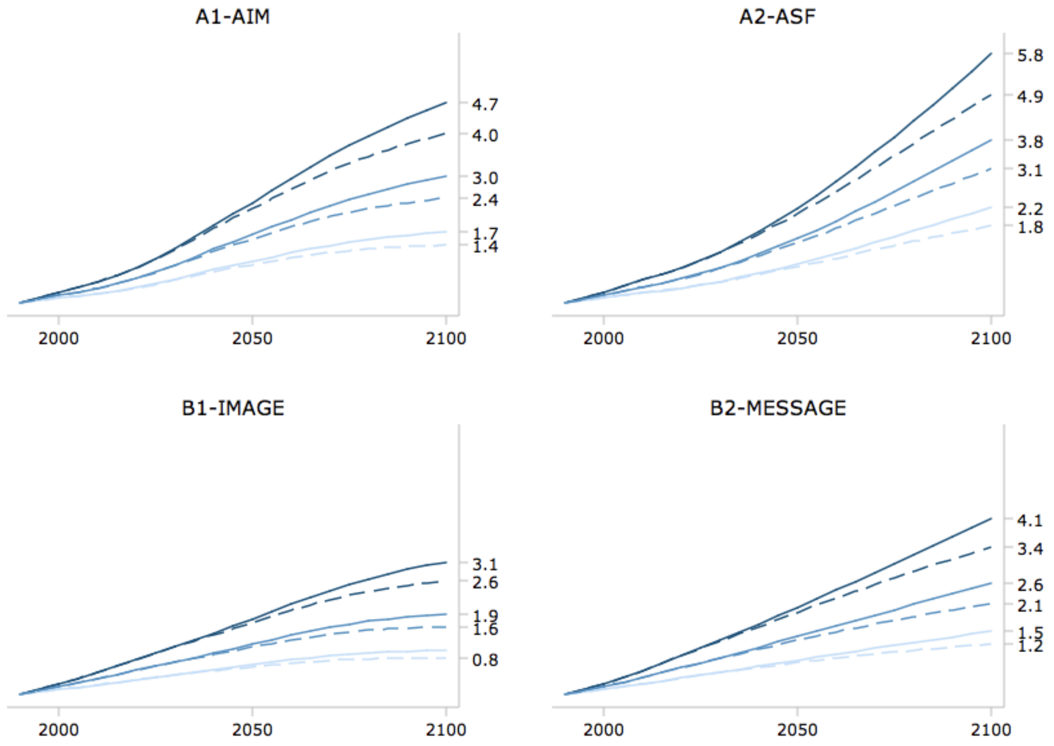
Source: IPCC and author's calculations.

Rather than mitigating 22 percent of the increase in temperature, under a proportional response only 15 percent of the increase is reversed. As before, with 40-60 percent of warming effectively locked-in, this decrease corresponds to 25-50 percent of addressable warming. Further, if a work-hours reduction has a significant impact on the rate of full employment[17] and productivity and fails to reduce emissions intensity, an even more pessimistic emissions response is possible. Such an outcome would be surprising given current research on the environmental impact of work hours.[18] Nevertheless, if a 1 percent fall in hours reduces emissions by only 0.5 percent, then only 8 percent of every degree of warming would be mitigated by our work-hours reduction.

[17] A properly designed work-hours reduction may be expected to increase employment when the economy is depressed. Our concern here is in the long run when the economy runs largely at full capacity.

[18] In addition to large responses found by Rosnick and Weisbrot (2006) and Knight (2012), disproportionately large responses were found by Hayden and Shandra (2009) and Devetter and Rousseau (2011). The latter noted that "consumption habits are effectively linked to working hours, and not just income.… Some of the most polluting forms of consumption are favored by long or very long working hours." On the other hand, Hertwich and Peters (2009) find a less than proportional response though it is not clear how much of this result is driven by development-driven dematerialization as opposed to production and income.

FIGURE 6
Estimated change in temperature (°C) since 1990—baselines and reduced hours—proportionate emissions response



Source: IPCC and author's calculations.

TABLE 2
Emissions response and percentage of addressable warming mitigated

	Emissions Elasticity	Climate Response (percent mitigation per degree of warming)	Effective Mitigation (percent mitigation per 0.3-0.6 degrees)
High	1.5	22	36-72
Proportional	1.0	15	25-51
Low	0.5	8	13-27

Source: IPCC and author's calculations.

Conclusion

For all practical purposes, some amount of climate change is inevitable. However, the amount of warming is very much under our control. In addition to reducing emissions by other means, a significant reduction in climate change is possible by choosing a more European response to productivity gains rather than following a model more like that of the United States. By itself, a combination of shorter workweeks and additional vacation which reduces average annual hours by just 0.5 percent per year would very likely mitigate one-quarter to one-half, if not more, of any warming which is not yet locked-in.

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Author contact: rosnick@cepr.net

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