# US Socio-Economic Futures

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US socio-economic trends will be important determinants of future energy demand, land use, and greenhouse gas emissions, as well as determinants of the impacts of climate change. These trends include demographic changes, trends in economic growth and its distribution across different sectors of the economy, and shifts in consumption patterns associated with changing lifestyles. Here I focus on demographic and lifestyle factors, highlight plausible alternative outcomes, and comment on their potential significance for future emissions. The timescale of focus is the next 20–100 years. In general, there is little that can meaningfully be said about these trends more than a century into the future, and the literature that attempts to do so is extremely sparse. It is taken as understood that none of these trends by themselves, nor even socio-economic factors considered together, would completely determine future emissions or vulnerability to impacts. Changes in technology, as well as political and institutional factors, in combination with socio-economic factors will co-determine emissions and vulnerability outcomes.

First, I discuss potential demographic outcomes in terms of population size, age structure, living arrangements (e.g., household size), and spatial distribution. Next, I discuss two ways in which demographics could affect future energy demand and emissions in the US: through impacts on macro-economic growth and through lifestyle-related compositional effects on aggregate consumption patterns. Finally, I discuss a few selected additional lifestyle factors that may be important over the next century.

## Demographic trends

Currently (i.e., in 2005) the US population is about 295 million and growing at approximately 1 percent per year. By 2020, population size is likely to be in the range of 300–350 million, based on projections from the United States Census Bureau (USCB); by 2100, this range expands to an astonishing 280–1200 million.[1] There are several points regarding this

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1 Unless otherwise noted, I use the US Census Bureau projections to represent the demographic outlook for the US, rather than projections from the UN or IIASA, primarily because the Census Bureau considers a wider range of future migration trends (both the UN and IIASA assume migration is zero beyond the middle of the century). I use Census Bureau projections made before data from the 2000 census were available (USCB, 2000), since this is the most recent set of projections available that gives a high and low range of

outlook that are worth considering. First is that the range of uncertainty in population size is relatively narrow over the next few decades and widens substantially only toward the middle of the century and beyond. Population size uncertainty grows slowly because growth is subject to substantial inertia built into the present size and age structure of the population.

Second, the large range for 2100 is driven by a wide range of migration assumptions, as well as alternative assumptions about fertility (assumptions about life expectancy vary as well but have a smaller effect on population size outcomes). Current net migration into the US is at a historic peak of about 1.3 million per year. The Census Bureau foresees the possibly that it could rise to 3.6 million per year by the end of the century, or fall to less than half the current rate at 560,000 per year. Few other major countries in the world currently anticipate migration to have such a substantial potential influence on future population size. In addition, fertility rates in the US continue to hover around replacement level of about 2 births per woman, substantially above the very low levels (below 1.5) prevalent in Europe. While demographers generally consider it extremely unlikely that countries in which fertility has already reached replacement level will see it rise substantially above 2 births per woman, a sustained fertility increase of only half a birth per woman or so can have a large effect on future population size. The Census Bureau uses a range of long-term fertility assumptions of 1.6–2.7. To put the high end of this range in perspective, during the post-World War II baby boom, total fertility rates in the US rose to over 3 births per woman (although it should be noted that this was a temporary change driven largely by changes in the timing of childbearing). For comparison on the low side, a fertility rate of 1.7 is below replacement level but, averaged across Europe, fertility is below 1.5, and in some countries as low as 1.1, so it is not unthinkable that the US will experience lower fertility rates (and therefore smaller population) than projected in the Census Bureau low scenario.

Third, it is worth putting the range of population size outcomes in perspective as well, because it is a reflection of the status of the US as a demographic anomaly in the developed world. While about 50 countries are expected to have smaller populations in 2050 than they do today, and while the populations of Russia and most of the states of the former Soviet Union are already shrinking (UN, 2004), the US is currently the third largest country in the world and is growing faster than developing countries such as China, Iran, and Thailand. If the US follows the high growth scenario from the USCB, its population could equal or exceed that of both China and India by the end of the century (depending on whether these countries follow either the UN medium or low projections). Even if the US follows the low scenario, its population will remain larger than it is

outcomes, and that extends to 2100. In 2004 the Census Bureau released an interim result for a single, middle projection to 2050 with base year data from the 2000 census (USCB, 2004), but has yet to release a longer term projection or high and low variants based on the 2000 census.

today until nearly the end of the century, in sharp contrast to the many European countries that face immediate or impending population declines.

Finally, it is worth noting that this range of population outcomes for the US is not well represented in IPCC emissions scenarios (SRES), for two reasons: first, the high scenario used in SRES was based on a projection from IIASA that assumed (as do all IIASA and UN projections) that migration would go to zero by the middle of the century, excluding the possibility of continued high migration as foreseen by the USCB. Second, the SRES scenarios do not include any low population scenarios for industrialized countries at all; this is an outcome that is simply not included in the SRES scenario set. As a result, the range of outcomes for the North America region (currently the US accounts for about 90 percent of the population of this region) in SRES is about 400–700 million, substantially smaller than the Census Bureau range.

Changes in age structure also span a substantial range. Currently, about 12 percent of the US population is aged 65 or older. Aging in industrialized countries, including the US, will accelerate temporarily over the next 30 years as the large baby boom cohorts age into the elderly age groups. By 2050, the USCB projects a range of 18–23 percent for the 65+ age group, and by 2100 the range expands to 19–30 percent. Thus in all plausible futures (including those with very high in-migration) the population becomes older, and the proportion of the population aged 65 and older could more than double by the second half of the century. Aging is most substantial in the low population growth scenario, due mainly to its assumption of relatively low fertility. It should be noted that more substantial aging than occurs in this scenario is possible, both because lower fertility is a possibility (as discussed above), and because this scenario assumes life expectancy at the low end of its projected uncertainty range. Pairing a low fertility assumption with the high end of the life expectancy range would produce greater aging, and there is no theoretical reason to prefer one pairing of these assumptions over another.

Another anticipated demographic change is shifts in living arrangements, including in particular a shift toward smaller household size (i.e., smaller number of members per household). As discussed below, several studies have pointed to changing numbers of households as an important driver in environmental change. Detailed projections of future living arrangements have only recently been carried out by demographers, and only for selected countries (e.g., Zeng et al., 1998; Prskawetz et al., 2001). A recent study aimed at identifying plausible bounds for future household size in the US (Jiang and O'Neill, 2005) finds that a range of 2.0–3.0 persons per household represent plausible extremes, compared to a current average size of 2.6. Most of this uncertainty range develops by 2050, and grows slowly thereafter. At the low end of this range, outcomes are driven by aging (fewer children as compared to adults leads to smaller households) as well as decreasing union formation rates (e.g., marriage, cohabitation) and increasing union dissolution rates (e.g., divorce). Whether this range of outcomes is sufficient to drive important changes in consumption patterns remains to be tested, but it should be noted that this change is likely to be much smaller than those anticipated in many developing countries where household size is substantially higher.

Finally, the spatial distribution of the US population could also plausibly undergo substantial shifts over time, but it is the demographic trend that has been least explored in terms of potential long-term outcomes. One way to structure thinking about this issue is to focus on two key components of spatial distribution trends: shifts in the relative growth rates of particular geographic regions, and shifts in the growth rates of urban vs. rural areas. Over the past several decades, the US has experienced net internal migration from the Northeast and Midwest to the South and West (Rogers and Henning, 1999). Historical urbanization trends are less straightforward. The US underwent rapid urbanization in the 19$^{th}$ and early 20$^{th}$ centuries. However, in the 1970s demographers were surprised to discover what came to be known as a "counter-urbanization" trend not only in the US but in other industrialized countries as well; i.e., growth in non-metropolitan areas began to outpace growth in metropolitan areas (Mitchell, 2004), and migration into rural areas was greater than migration into urban areas. This trend turned out to be short-lived; during the 1980s growth in urban areas again predominated. However, the 1990s saw a resumption of the counter-urbanization trend in the US, with migration into rural areas again outpacing migration into urban areas (Fulton et al., 1997; Fuguitt and Beale, 1996).

There is no consensus on the most likely pattern of spatial growth in the future. While over the shorter term a trend toward continued growth of the south and west seems likely, in the longer term uncertainty is high. The potential role of counter-urbanization in the future is also unclear. Geographers and economists have proposed two broad types of explanations for counter-urbanization trends: that they are driven by changes in residential preferences, or that they are driven by changes in spatial distribution of employment opportunities (Renkow and Hoover, 2000). Residential preferences for less urban lifestyles, perhaps driven by urban disamenities such as crime and crowding, could prolong recent deconcentration trends. Economic activity could move to less densely population areas if structural shifts favor activities that have less to gain from the benefits of agglomeration in cities. For example, shifts toward services, information technology development, and international competition in a globalizing world have been offered as explanations for restructuring-driven spatial deconcentration in the recent past.

In summary, there are a number of possible scenarios for future demographic change in the US. By the end of the century the US could have a population of more than 1 billion, have surpassed India and China, and still have less than 20 percent of its population above age 65. This quadrupling of the population, driven by high immigration and relatively high fertility, would be associated with substantial shifts in the racial and ethnic mix in the population and could plausibly be associated with a growing number of coastal mega-cities. In contrast, by the end of the century the population could be somewhat smaller than it is today, with a third or more of its population 65+. It is also possible that an increasing counter-urbanization trend could lead to a greater dispersal of the population over the land.

## Macro-economic growth effects

Aging could have substantial impacts on economic growth (and therefore, all else equal, on emissions). There is considerable evidence that, in general, age structure can be an important determinant of economic growth rates under some conditions. For example, the so-called Asian economic miracle, during which high growth rates have been sustained in many East Asian countries over the past decade or two, has been convincingly shown to have been driven in part by a "demographic window" of opportunity (Bloom and Williamson, 1998). Rapid declines in fertility temporarily create an age structure with a labor force that is large relative to the size of dependent age groups (children and the elderly), providing favorable conditions for both household and public savings rates. Later, continued low fertility and lengthening life expectancy leads to a shift in age structure toward large old-age dependency ratios. A corresponding decrease in labor productivity (for the population as a whole), savings, and possibly consumption could lead to substantial decreases in economic growth rates, as well as challenges to intergenerational transfer schemes such as pay-as-you-go pension systems and public health care.

Research on this issue has been largely confined to economics and economic demographers, and environmental implications have rarely been considered. Dalton et al. (2005) have recently introduced age structure into an energy-economic growth model of the US economy and found that in the long-term (50–100 years) aging in the US could reduce $CO_2$ emissions by a third relative to an identical scenario that does not account for the effects of aging. In fact, the aging effect on emissions can, under some conditions, be larger than the net effect of technological change. This result is preliminary in the sense that it does not yet account for the potentially ameliorating effects of international capital flows and of extensions to working life-spans. However, historical trends in industrialized countries have been toward decreasing, not increasing, working lifespan (MacDonald and Kippen, 2001). In addition, rising educational enrollment rates have decreased labor force participation at young ages, and falling retirement ages have decreased participation at older ages, leading to a steady decline in lifetime hours of work (Ausubel and Gruebler, 1995). It cannot blithely be assumed that this trend will be easily reversed; less work and more leisure has been the preferred direction in industrialized countries for 150 years.

This is not to say that the US economy will inevitably come under substantial pressure from aging. Dalton et al. (2005) find substantial aging effects only in the demographic scenario with the most aging. In midrange demographic scenarios, the US outlook for labor force is one of the most favorable of any industrialized country; one study (MacDonald and Kippen, 2001) finds that across a range of scenarios, the absolute size of the US labor force increases at least through 2050, while in many European countries, it falls in almost all scenarios, even accounting for immigration.

## Demographics, lifestyles, and consumption patterns

Both the level and composition of household expenditures differ across households of different type (Paulin, 2000; Deaton et al., 1999; Bosch-Domenech, 1991). Characteristics such as household size, age of the householder, composition (measured as the number of members in particular age classes), and urban/suburban/rural status have been shown to be important for certain goods in particular contexts. For example, energy studies literature has identified household characteristics as key determinants of direct residential energy demand (Schipper, 1996; Poulsen and Forrest, 1988; Schipper et al., 1989). Household size appears to have an important effect, not only on energy use per household but on a per capita basis as well, most likely due to the existence of substantial economies of scale in energy use at the household level (O'Neill and Chen, 2001). Research focusing specifically on transportation has found substantial differences in travel demand across households that differ in the age and gender of the householder, household size and composition, and family type (Prskawetz et al., 2001; Carlsson-Kanyama and Linden, 1999). The lifecycle concept has been used as a framework for capturing variation in travel demand across households that differ by some combination of family size, family type, age of the householder, and marital status (Greening and Jeng, 1994). It has also been suggested that gender-specific cohort effects may be important, since younger generations, and women in particular, have different travel habits than previous generations (Buettner and Gruebler, 1995; Spain, 1997).

These types of differences across households can be thought of as arising from lifestyle differences associated with households that differ in their demographic characteristics. In general, lifestyle is taken to mean a specific pattern of activity and consumption; usually, lifestyle is assumed to involve factors above and beyond the influence of income and prices. For example, lifecycle variations in travel demand can be though of as arising in part from the fact that members of young, middle-aged, and elderly households generally have different lifestyles: different patterns of daily activity involving work, leisure, trips for children, etc.

The existence of lifestyle differences across households with different demographic characteristics raises the possibility that as the US population shifts in composition across these categories of household types, aggregate consumption could be substantially affected, with consequences for energy demand and emissions. However, only a few studies have tested this hypothesis within medium to long-term energy and emissions scenarios. Prskawetz et al. (2001) focus on personal vehicle use in Austria, and demonstrate that over the next 40 years, projections that do not account for the effect of the aging of the baby boom cohort, and an associated shift toward smaller household size, could miss a possible peak and subsequent decline in travel demand anticipated from an age-structured model. Dalton et al. (2005) project total energy demand for the US accounting for the age structure of the population, and find substantially less demand in scenarios with relatively rapid aging. They find that this effect is largely driven by changes in the level of aggregate consumption, not by changes in the consumption mix across different categories goods. It is plausible that other demographic trends, such as changes in spatial settlement patterns, could have substantial implications for energy demand (particularly in transportation), but this has not yet been tested within longer term scenario analysis.

### Other lifestyle changes

Aggregate consumption can change not only due to shifting population composition, but also due to changes in lifestyles (activity and consumption patterns) within population groups or across the population as a whole. A number of such "lifestyle changes" have been considered as socio-economic scenario elements; two—diet and travel—are briefly discussed here.

Diet is a key factor driving future land and energy use scenarios. Typically, the proportion of calories from meat increases with rising incomes, but future trends in industrialized countries that have already transitioned to more meat-based diets are unclear. Since production of meat is more land- and energy-intensive compared to production of staples, shifts in dietary preferences are one of the most important determinants of future land use and emissions from agricultural sectors (Fischer and O'Neill, 2005). Studies that find that global land use by the agriculture sector could decline in the coming decades are driven in part by optimistic dietary assumptions, along with assumed increases in technology-driven agricultural productivity (e.g., Waggoner and Ausubel, 2001).

Travel-related behavior is a second important example. Energy use per person per unit of time is much higher for travel than for other activities (Schipper, 1989), and therefore future trends in travel activity are likely to be an important determinant of energy use and emissions. While income and prices are important determinants of travel behavior, lifestyle choices also play an important role. Approaches to scenario building that used a time-based activity approach have been advocated as a means of capturing the potential for lifestyle choices to be incorporated in projections (Schipper, 1989). One global scenario (Schaefer and Victor, 1997) has taken an activity-based approach, positing a fixed fraction of time and income devoted to travel, and foresees mobility (distance traveled per year) per person in the US more than doubling by 2050, as incomes rise and travel shifts toward faster modes of transport (including air travel). However, scenarios based on alternative time budgets for travel—reflecting different lifestyle choices—were not tested.

Transportation behavior is also a good example of how technological and lifestyle changes can be intertwined. For example, changes in information technology may play an important role in residential locations (discussed above), in the division of work between home and place of employment, and in commuting patterns. However, it is unclear whether the net effect will be toward increasing or decreasing energy demand (Allenby and Unger, 2001). Energy use at home could be greater than energy use at a place of employment. It is also possible that, rather than decreasing travel by reducing the need for commuting, information technology could increase travel demand by facilitating the development of larger and more spatially diverse networks of colleagues and customers.

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