To do its part in keeping climate change to tolerable levels, the United States needs to cut its carbon emissions *at least* 80% below 1990 levels by 2050. That's not just a matter of decarbonizing the electricity sector; it means changes in everything from aviation to steel manufacture, and reducing not only CO_2 but also other pollutants like HFCs and black carbon.

In a new book, Michael Gerrard and John Dernbach have assembled a team of authors to look at thirty-five different issue areas and figure out the legal actions that will be needed to drive this change. Their work builds on earlier planning efforts, particularly in California. The book runs more than 1100 pages and weighs in at over four pounds. Even the title has heft: *Legal Pathways to Deep Decarbonization in the United States.* I can't claim to have plowed all the way through, but the book clearly deserves credit for moving the ball forward on a very big set of problems. Many of the necessary changes are linked: we need to electrify cars, which means we need much heavier reliance on renewable energy. And relying heavily on renewables means we need a host of other measures to deal with intermittency issues, including better long-distance transmission, expanded demand response to synchronize power demand with supply, batteries for short term storage, and other technologies for longer-term energy storage. Each of those poses both technological and regulatory challenges.

The good news, Gerrard and Dernbach report, is that hitting the 80% target is technologically and economically feasible. But it's going to be a heavy lift, requiring coordinated planning across many sectors and over three decades. (Socialism!) That itself, it seems to me, poses major institutional challenges.

To be effective, planning has to be flexible enough to take into account new developments, such as unexpected technological breakthroughs. It also needs to rely on markets where possible, because there's a limit to how much the government can effectively micromanage the economy. Yet at the same time as flexibility is required, so too is continuity of commitment. Over thirty years, we can expect a lot of political shifts and changes in government. How do we ensure that these do not undermine progress?

The needs for flexibility and commitment are at cross-purposes. To be flexible, we want to keep lots of options open and avoid big investments that will lock us into pathways that might turn out to be suboptimal. But those strategies also make it easier to give up the fight later. To maintain commitment, we would like to make big upfront investments that will drive downstream actions, thereby sacrificing

flexibility. We need to somehow negotiate these tradeoffs.

There's no easy answer to this problem, but I have two suggestions. The first is to emphasize pathways that lead to lower prices, so that market forces will keep up the pressure for change even when political will flags. This has been a successful strategy for wind and solar, where regulatory pressures and funding for innovation have cut prices to the point where the economics are favoring renewables. The second is to try to shift the political balance of power by moving the economy and jobs toward industries with a stake in decarbonization, most obviously renewable energy but also increasingly the auto industry and utilities.

Deep Decarbonization surely won't be the last effort to model the U.S. energy transition and the necessary regulatory measures. But it's an important first step – and as they say, every journey of a thousand miles begins with a single step.