GREEN ENERGY ECONOMIES

THE SEARCH FOR CLEAN AND RENEWABLE ENERGY

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A Green Energy Manufacturing Stimulus Strategy

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Manufacturing and the Environment Need Each Other

At the most basic level, both manufacturing and environment exist in order to create. Manufacturing creates goods; the environment creates life. The long-term challenge is to create goods while maintaining creation of life. We need to create goods that are necessary to build a sustainable society. If we do not rebuild our man-made environment, the prospect for the future of our global civilization is not good, as several authors have documented.[1]

How would we rebuild the society? It is easier to look at the problem by dividing "society" into a set of sectors: transportation, energy, manufacturing, urban structure, buildings, and agriculture. Each sector of the economy relies on manufactured goods, and each sector requires a distinct set of manufactured goods to become environmentally sustainable. Let's look at each sector in turn.

Sustainable Sectors

First, dependence of transportation on oil is now 94 percent for the cars, trucks, trains, planes, and ships that are used as its main sources of machinery; even roads need oil in the form of asphalt.[2] Since oil will not last forever, is very polluting, and emits greenhouse gases, we need to switch to the use of renewable electricity for running this huge vehicle fleet, which will involve an increased production of electric trains, electric cars, smaller electric trucks, and ships, as well as planes kept aloft with sustainably produced biofuels.

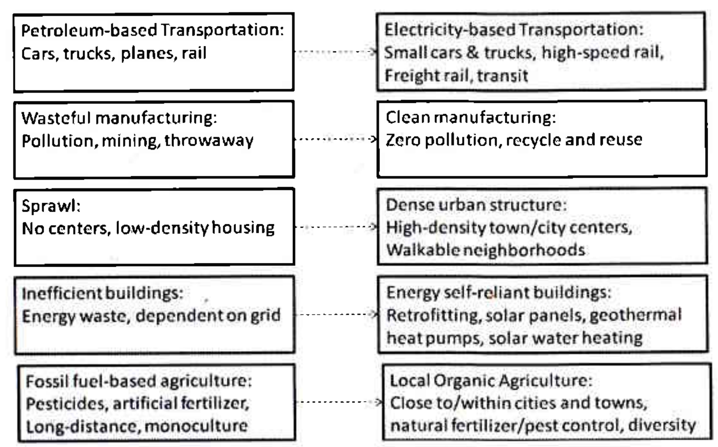
Second, energy production is now dominated by fossil fuels, that is, petroleum for transportation, coal for electricity, and natural gas for electricity, heating, and cooking. Eventually, we will have to shift almost completely to renewable technologies such as wind, solar, and geothermal if we are to avoid disruptions caused by declining supply, climate change, and collapsing ecosystems. Instead of drilling rigs, mining equipment, refineries, and pipelines, we will need wind turbines, solar panels, and ground source heat pumps, along with a rebuilt national electric grid that carries electricity throughout the continent.

Third, manufacturing, service, and household economies use newly mined materials, directly or indirectly, as inputs and discard products after use and/or pollute in the process of production. Mining and trash disposal will have to be replaced by recycling systems and reusable design; polluting methods of manufacture will have to be replaced by clean methods.

Fourth, the bulk of any future building will need to be in the direction of denser town and city centers, and away from the low density of sprawl. The denser (i.e., the closer together and taller) the residential and commercial buildings, the easier it will be to adopt an electric transportation system, to economize on energy use (because large buildings are more energy efficient), and to restore natural ecosystems (because much less space will be needed).

Fifth, new buildings as well as most older structures will need to be retrofitted to be energy-efficient if not energy self-sufficient. This will require much of the equipment mentioned for energy, such as solar panels, but it will also require new materials and insulation.

Figure 1
Creating a Sustainable World Will Require Transforming Many Sectors of the Economy from Spatially, Energetically, and Materially Wasteful Sectors into Efficient, Clean Ones.



Sixth, provision of food will need to change from a long-distance, industrial model to a more local, organic, labor-intensive food system. Intensive agriculture that does not use pesticides or artificial fertilizers but requires large amounts of high-skill labor will require a different set of tools and infrastructure for a new set of farmers.

An economy that is producing machinery and goods for an electric transportation system, a renewable energy sector, a dense urban environment, a recycled-materials-based manufacturing sector, energy-efficient buildings, and sustainable agriculture—will provide the support for a thriving manufacturing sector if all of these systems are designed in a mutually self-reinforcing way.

Why Manufacturing Is Essential for a Wealthy Economy

We need manufactured goods to create an environmentally sustainable society, and we need an environmentally sustainable society in order to have a manufacturing sector. But does the economy really need a manufacturing sector? Aren't we a service economy now? Can't the United States just let everybody else manufacture all of those nice new green products and let us innovate and market?

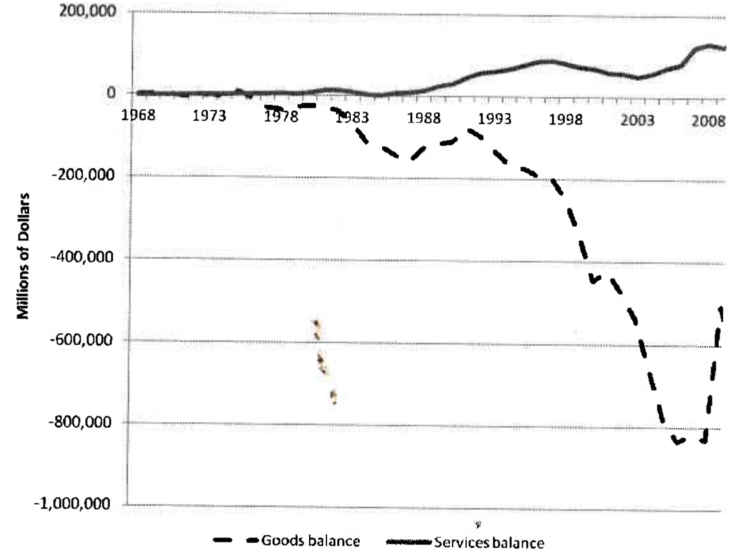
The United States needs a strong manufacturing sector for a number of reasons. The case of the United States is a good one to examine because, for most of the twentieth century, the United States was the most dominant manufacturing economy in the world, and the decline in manufacturing has brought a host of problems in its wake.[3]

Buying More Than We Sell

The first problem associated with a declining manufacturing sector is that the United States has not been able to sell enough goods and services in exchange for goods and services from abroad, creating a huge trade deficit. The decline in manufacturing has contributed to this problem because international trade is mostly in goods, not services. That is, 80 percent of interregional trade is in goods, and only 20 percent is in services—as is the case with the United States.[4] The United States cannot possibly trade enough *services* for the volume of goods that it receives, and has instead been running up trade deficits, starting from soon after its manufacturing sector began to decline after 1968.[5] The United States has been making up for this shortfall ever since by exchanging dollars rather than goods. As its dependence on oil has expanded, it has provided dollars for oil as well.

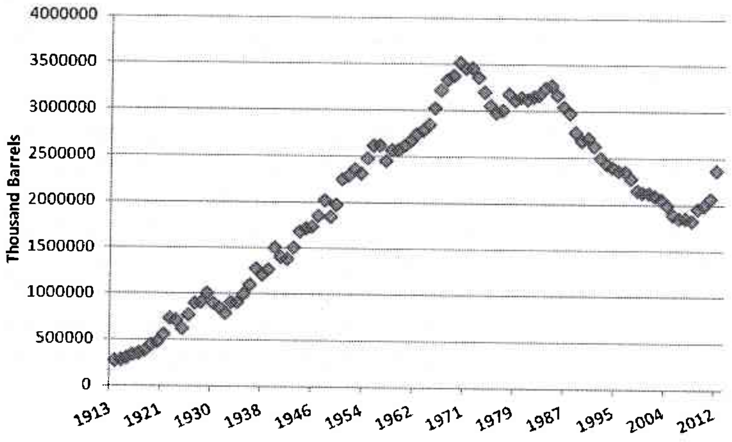
So the trade deficit, which is the shortfall between what is bought from the rest of the world and what is sold, is a manifestation of both the economic unsustainability of the decline of manufacturing and the ecological unsustainability of the decline of petroleum output, which affected the United States first. Oil production peaked in the United States in late 1970,[6] even though it had been the "Saudi Arabia" of oil before then.

Figure 2
Trade Balance of the United States, 1968 to 2010, in Millions of Dollars



Source: U.S. Department of Commerce, Bureau of Economic Analysis, see note 5.

Figure 3
US Field Production of Crude Oil: Petroleum Production in the United States Peaked in 1970



Source: U.S. Energy Information Administration (http://www.eia.gov/dnav/pet/hist/LeafHandler.ashx?n=pet&s=mcrfpus1&f=a)

Since the dollar is practically the only currency used to buy oil, the United States has been able to get away with paying for goods and oil with printed paper. If the dollar should ever stop being accepted in lieu of goods, then the United States will be in serious trouble economically because it does not produce the goods needed for the service sectors that have become the bulk of the economy.

Services Need Manufactured Goods

The second reason that manufacturing is important is that the service industries, which together constitute two-thirds (66.8 percent as of 2010) of the economy, are dependent on manufactured goods for their existence and technical progress. We can see why it is so dependent on a predictable supply of manufactured goods by looking at what is called the "value-added" percentage that a particular industry contributes to the economy. Often, writers discuss the total revenue of an industry, but by doing so, the writer includes inputs from other industries. For example, the manufacturing sector as a whole received a revenue of $4.5 trillion[7] in 2009, but only added $1.6 trillion to the economy[8] because the rest of the revenue, besides the value-added percentage, has been created by other sectors such as the service industries. By using value-added as a measure, we can get a better idea of how much a particular slice of the economy actually contributes to the economy as a whole.[9]

Retail and wholesale service sectors together contributed 11.3 percent to the value-added portion in the economy. They are clearly dependent on manufactured goods because they retail and wholesale these goods. If, say, the value of the dollar collapsed, Walmart and most other retailers would have much less to sell because imported manufactured goods would become too expensive. The transportation and warehousing sectors constitute 2.8 percent of the economy and use equipment which must be manufactured. Information industries, including publishing, software, TV, and phones, use an enormous amount of equipment, and constitute 4.5 percent of the gross domestic product (GDP). Healthcare services, at 6.8 percent of the value-added portion, also need equipment; a hospital without surgical instruments, diagnostic instruments, and pharmaceuticals would not be a hospital at all. Hotels and restaurants use buildings and food equipment, and constitute 2.7 percent of the value-added portion. Professional and business services, at 12 percent, either manage the use of equipment or use equipment for their operations. Other parts of the economy which are neither manufacturing nor service industries rely on considerable quantities of equipment and machinery: construction (3.8 percent), mining (1.7 percent), utilities (1.9 percent), and agriculture (0.9 percent).

Even real estate, at a whopping 13.2 percent of the value-added portion in 2009, basically involves buying and selling buildings which are assemblages of goods put together with construction machinery. Finance and insurance

sectors (8.3 percent) take the surplus from all the other sectors of the economy. That is, they recycle the profits and rent all other industries generate. They use the wealth generated by the service industries which in turn depend on the manufacturing sector, as well as the wealth generated by manufacturing. The financial service industries do this by using computers and communications equipment.

The United States cannot assume that it can simply import all the equipment it needs. The United States may not have anything that the trading countries would want in return. Even if the United States were to sell all its assets, there are only so many to sell. Factories would be the best investment because a factory would create goods that could be sold abroad. But if the United States does not have many factories to buy and if it does not have the skilled workers and engineers needed to maintain world-class facilities, then foreigners would be less willing to hold dollars to buy assets. Thus, it is not only beneficial but also prudent to produce green technologies in the United States as a way to generate jobs.

Table 1
United States GDP by Industry, Value-Added, 2009. Services Constitute about Two-Thirds of the Economy, with Manufacturing and Other Production Comprising about One-Fifth, and Government the Rest

United States GDP by industry, value-added, 2009	
Agriculture & mining	3
Utilities	1.9
Construction	3.4
Manufacturing	11.2
Wholesale & retail	11.3
Transportation	2.8
Information	4.5
Finance and insurance	8.3
Real estate	13.2
Professional & business services	12
Health services	6.8
Hotel & food services	2.7
Entertainment, education, other services	4.4
Federal government	4.3
State & local government	9.3

Source: U.S. Department of Commerce, Bureau of Economic Analysis, see note 9.

Manufacturing Leads To Innovation

It is also becoming clear that by basing manufacturing and green manufacturing in the United States, the country retains its capacity for innovation as well. Put negatively, when American manufacturing industries are relocated abroad, US competence to create engineering and technological innovations weakens.[10] In addition, when one industry disappears, then others suffer because they lose the capacity to interact with "sister" industries. For instance, the automobile industry becomes less innovative partly because many of its support industries, such as domestic machine tools, have left.

The importance of keeping as many industries together as possible stems from the fact that an economy is an ecosystem of a kind, and manufacturing is an ecosystem within the wider economic ecosystem.[11] Like an ecosystem, an economy needs to have most or all of its main functioning parts in the same region in order to thrive. All the various parts of the economic system co-operate as much as they compete, and they need a certain closeness or proximity to other "co-evolved" industries in order to innovate and grow.

The United States was the first region to contain a full suite of modern manufacturing industries, and this power was the foundation of its rise as the most important economic, political, and military power.[12] The decline of this manufacturing base was the single most important reason for the decline of the middle class in recent years, and an aggressive program of green reindustrialization is now crucial rebuilding middle-class prospects.

Manufacturing Anchors Middle-Class Jobs

The "Great Recession" that started in 2008 is above all a problem of the lack of jobs. The employment picture has been transformed by the decline of manufacturing in the United States—the manufacturing sector is the main engine of job creation in a modern economy. While services have picked up much of the slack, the shortfall has been severe, and much of the service sector is composed of jobs that are lower paying than those typically associated with the manufacturing sector. Let us look at how different sectors have fared in the past several decades.[13]

From the 1950s to 1968, manufacturing as a percentage of employed persons barely declined from 28 to 25 percent. After 1968, however, the rate of decline roughly doubled, and manufacturing now constitutes only about 9 percent of the total US employment. By comparison, manufacturing in Germany still employs about 21 percent of German workers. In terms of GDP, the "value-added" percentage in the United States declined from about 25 percent in 1968 to 11.2 percent in 2009. So what sectors picked up the slack in terms of both GDP or overall national output, and employment?

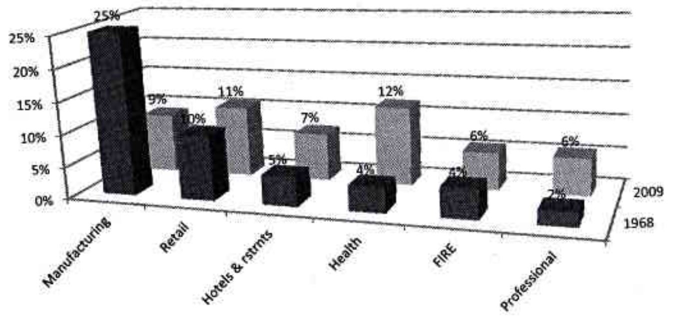
The problem of the US economy is that the sectors that took manufacturing's share of GDP did not increase their share of employment, while the sectors that

increased their share of employment did not increase their share of GDP. In other words, some sectors got richer, relatively, but did not increase their number of employees appreciably, and some sectors became relatively poorer per worker. Manufacturing, on the other hand, has for the most part pulled in as much income for employees as it has received from the economy—in other words, it is the quintessential middle-class sector.

Scholars of African development have used the term "structural disarticulation" to capture this concept of the skewing of an economy.[14] These scholars claim that there is an "unevenness in sectoral development," which in the African context means that most people are in the low-income-generating occupation of agriculture, while most of the wealth is generated by industry or mining. We can measure this with a "sectoral ratio", that is, we can find the ratio of the value-added percentage of the GDP, divided by the percentage of the total employment accounted for by a sector.

A sector with a sectoral ratio larger than one is richer, relative to the economy as a whole, while a sectoral ratio less than one indicates that a part of the economy contains a large amount of low-wage jobs. When a sector with a high ratio grabs more of the economy, then sectors that have lower ratios have less of the economy to provide to the same or more employees. So, the economy becomes more imbalanced as people are squeezed out of the middle class, particularly out of manufacturing.

Figure 4
Change in Employment for Selected Sectors, as a Percentage of the Work Force, from 1968 to 2009. Note the Shrinkage in Manufacturing and Rise in Low-Paying Services

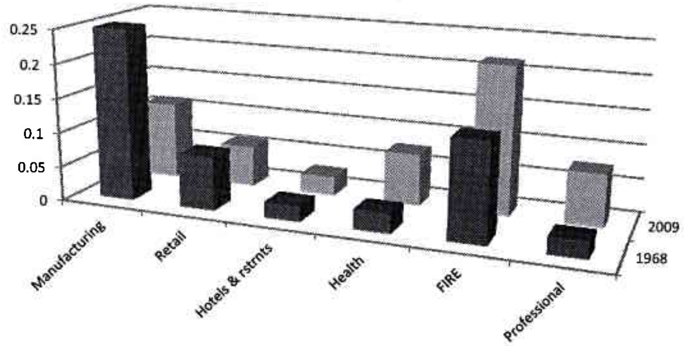


	Manufacturing	Retail	Hotels & rstrnts	Health	FIRE	Professional
■ 1968	25%	10%	5%	4%	4%	2%
▨ 2009	9%	11%	7%	12%	6%	6%

Source: Department of Commerce, Bureau of Economic Analysis, see note 13.

Figure 5

Change in Gross Domestic Product (GDP) for Selected Sectors, as a Percentage of the GDP, from 1968 to 2009. Note the Decline in Manufacturing and the Increase in Low-Employment, High-Paying Services

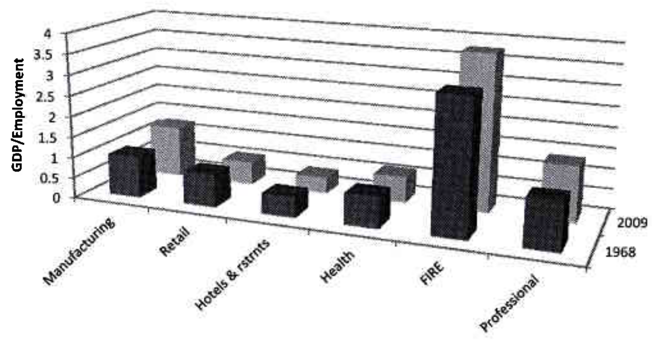


	Manufacturing	Retail	Hotels & rstrnts	Health	FIRE	Professional
■ 1968	0.25	0.078	0.022	0.028	0.142	0.024
■ 2009	0.112	0.059	0.027	0.075	0.215	0.076

Source: Department of Commerce, Bureau of Economic Analysis, see note 13.

Figure 6

Change in Ratio of Gross Domestic Product (GDP) to Employment Percentage for Selected Sectors, from 1968 to 2009. Because of their High Ratio, Since Finance, Insurance, and Real Estate (FIRE) Grew in GDP, They Didn't Add Much in Employment, Squeezing the Rest of the Workforce



	Manufacturing	Retail	Hotels & rstrnts	Health	FIRE	Professional
■ 1968	1	0.79	0.49	0.75	3.23	1.14
■ 2009	1.24	0.55	0.38	0.63	3.77	1.36

Source: Department of Commerce, Bureau of Economic Analysis, see note 13.

Finance Went Up, Most Services Went Down

Finance, insurance, and real estate (FIRE) in the United States saw the biggest increase in its sectoral ratio; from 1968 to 2009, its share of employment rose from 4.4 to 5.7 percent, but its share of GDP rose from 14.2 to 21.5 percent. So, its ratio rose from about 3.2 to 3.8. Thus, FIRE grabbed 7.3 percent more of the economy, about half of the 14 percent of the GDP lost by manufacturing from 1968 to 2009.

Professional, technical, and scientific services moved from 2.1 to 5.6 percent of employment, while GDP rose from 2.4 to 7.6 percent for an increase in ratio from 1.1 to 1.4. Thus, about a quarter of the employment of the manufacturing sector loss went to this sector, which is composed of accounting, legal, advertising and management, and scientific and engineering consulting.[15] These are so-called "knowledge workers," who were supposed to take up the slack for manufacturing—which they only partially did.

On the other hand, several service sectors registered a *lower* sectoral ratio with increasing employment. The poster child for a lower standard of living is the hotel and restaurant sector. From 1968 to 2009, employment in this sector went from 4.5 to 7.2 percent, while the GDP rose from only 2.2 to 2.7 percent, with the ratio declining from 0.5 to 0.4. Health and social services saw a rise in employment from 3.8 to 11.9 percent, but only a rise in GDP from 2.8 to 7.5 percent, and thus, from 1968 to 2009, the ratio lowered from 0.7 to 0.6. Perhaps surprisingly, the percentage of retailing in the economy decreased, from 7.8 to 5.9 percent, but the percentage *employed* actually went up, from 9.9 to 10.8 percent. Thus, the sectoral ratio for retail jobs is at about one half the level of manufacturing jobs. If we add up the hotel, restaurant, health, and retail sectors, we see that from 1968 to 2009, the GDP rose from 12.8 to 20.5 percent for these sectors in the aggregate, while employment increased from 18.2 to 29.9 percent; the sectoral ratio for this group stayed about 0.70—and this included doctors; so, the relative income for most workers is much less. This sector gained almost 12 percent of the workforce, while manufacturing was losing about 15 percent. Thus, the rise in employment of a relatively low-paying set of industries accounts for most of the loss of the middle-class manufacturing sector (see Note 14 for sources).

Thus, a small part of the job force is doing much better, specifically in the "FIRE" sector, plus some technical occupations. However, manufacturing has declined and shed much of its workforce into sectors that are providing much less income per employee than manufacturing. These sectors include hotel and restaurant work, health care, and retailing.

Creating a Larger Middle Class

Owing to the dynamics described above, the economy is imbalanced. What it really needs, if it is to support a large middle class, is a large manufacturing sector contributing 20–25 percent to the GDP, with a small FIRE sector, and a reasonable services sector.

How does the United States grow manufacturing back to, say, the level of Germany, or 20 percent of the workforce? The United States would need to increase the share of employment in manufacturing by about 11 percent of the overall workforce, or some 14 million workers. Since the unemployment rate is 8.5 percent as of December 2011, another 5.2 percent of the employable population is employed part-time but wants to work full-time, and another 1.3 percent is too discouraged to look for work. For a total population of 22.2 million,[16] the United States could create 14 million jobs and not even exhaust the existing pool of unemployed or underemployed laborers.

It may also be possible for many millions of workers who have gone into restaurant, retail, or health jobs that pay less, to obtain jobs that pay more, and to increase their contribution to the long run vitality of the economy.

Green Manufacturing is Necessary for a Revival of Manufacturing

Manufacturing that is used to create a green society could generate about one-third of those 14 million jobs; a strategy to do so will be described in detail later. However, it is important to note that these green manufacturing jobs by themselves would not carry the entire load. This is to be expected because the manufacturing sector produces an enormous assortment of goods, from furniture to silverware, not all of which will be included in the transportation, energy, building, and food sectors which are the focus of green economics. Nevertheless, there are two important reasons why it would not be possible to revive manufacturing, and thus the economy, without spearheading reconstruction with green manufacturing.

Replace Resources with Machinery

First, green manufacturing will be required to replace the use of natural resources with machinery, and this need can lead to a large demand for manufactured products. In addition, manufacturing cannot continue if it depends on rapidly depleting resources; the yin of manufacturing requires the yang of a sustainable environment. A green energy economy will depend on the construction of machinery (equipment) such as wind turbines, solar panels, and even geothermal and tide/wave equipment in the U.S. Machines will create electricity by using, for all practical purposes, free fuel, that is, the wind, sun, and earth as energy sources. In a green economy employment will shift from the manning of drilling rigs and the maintenance of refineries and pipelines, to manufacturing wind turbines and solar panels, and then installing them on land or on buildings. Moreover, the processes for making manufactured goods will have to change in order to make recycling and reuse easier to carry out, thus giving engineers and machinery makers more work to create recyclable products.

In a sense, replacement of mining and fossil fuels with machinery will constitute the completion of the Industrial Revolution. While the Industrial Revolution began with the use of coal, this resource was favored because it was convenient and fitted well with the technological capabilities of the times. Prior to the use of coal an industrial revolution had occurred in many parts of the world, particularly in Europe, based mostly on the harnessing of wind and water power. Windmills ran grain mills and water wheels and provided the main power source for basic machining as well as textile and metal production before coal took over.[17]

But the essence of the Industrial Revolution was not coal, or later, petroleum, but machinery.[18] Industrial machinery is at the center of the manufacturing ecosystem because it is with machinery that we make all the products and the infrastructure that we actually use. Virtually no industrial machinery is used by consumers in everyday life; but without it, modern society would not exist. Within the industrial machinery "niche" there exists an even smaller and more critical central niche whose technologies can collectively reproduce themselves and produce the industrial machinery which indirectly powers industrial civilization.[19] These classes of machinery and equipment—such as machine tools, which create the metal parts of all other machines, including machine tools themselves—I call "reproduction machinery," as opposed to "production machinery," which is used to make the final consumer goods and infrastructure.

Machine tools are the master tools for shaping metal for embedding a form or structure on a material. An essential piece of reproduction machinery is the device that creates the energy that is used in the industrial process, and the first such device was the steam engine, invented by James Watt in 1776. We now use a particular kind of steam "engine," which is really a turbine, in electricity-generating plants which now use coal, hydropower, or other fuels. But what we are moving toward are renewable energy machines, such as wind turbines and solar panels, which for the first time are not tied to a fuel. They create energy, as far as we are concerned, from the machine alone—although the siting and actual production of the machine will depend on the characteristics of the wind and sun (and earth and water) in a particular location.

From Controlling Territory to Innovating

The effects of this shift on civilization will be enormous (Michael T. Klare, in this volume, explains the current position of fossil fuels and raw materials in the structure of international power). When economic power is based on a material that is specific to a particular territory on the surface of the planet, then economic power is determined by political control over that space—that is, political power determines economic wealth, not technological prowess, knowledge, or skill. This is an oversimplification because even the Saudis need sophisticated equipment to extract and refine their oil. But the fact remains that in the case of raw materials political power can be maintained simply by controlling a particular space.

When, on the other hand, economic power comes from knowledge and skill, then any country can learn to create that power, create wealth within their country, and can at least challenge their more powerful neighbors and retain some control over their own territory. Perhaps this is one of the reasons that the Chinese government has decided to encourage and create domestic renewable energy industries—they know that renewable technologies give them the independent capability to generate electricity, and this capability therefore limits the power that other countries have over the Chinese. The same considerations follow with regard to a shift from mining to recycling. Thus, a shift from fossil fuels to renewable energy technologies will have profound geopolitical repercussions and may well become a national security priority.

Creating Manufacturing Ecosystems

So producing energy from machines instead of fossil fuels will provide a market for more machinery, thus reinvigorating manufacturing in general. The second reason that green energy manufacturing can help resuscitate the wider manufacturing sector is that these final products, such as high-speed rail trains or wind turbines, will also serve as the center of their own industrial eco-subsystems, just as the automobile manufacturing ecosystem has served to anchor much of the American economy for a great portion of the post-World War II (WWII) period. For instance, Jonathan M. Feldman has shown how new transit manufacturing could help suppliers of components transition from brakes to motors, from using various kinds of steel to fabricating shells of subway cars, and from developing on-board information systems to manufacturing and installing electrical systems.[20]

Meanwhile, green manufacturing and recycling will be required to minimize the use of depleting and polluting resources. They will also be vital because large parts of the manufacturing landscape will change as the use of natural resources, particularly oil, declines, so that whole new industries will be needed to replace these. When fossil-fuel industries are replaced, the machinery subsystems that have been supporting the current machinery industries will again thrive.

A Green Economy Will Have a Different Mix of Industries

A shift to a green energy economy will lead to a shift in the distribution of employment, with less people needed in the transportation sector but more in the energy and construction sectors. In a green economy, significantly fewer cars may be needed, and if so, some other sectors must take on the employment role automobiles occupied in the post-WWII period. This could be accomplished by a combination of an expanded rail industry and a large wind turbine and solar panel industry, together with a scaled-back electric car industry and construction of dense town and city centers and intensive agriculture.

Cars support a vast ecosystem of parts makers, metal makers, electronics makers, tire makers, and so on. Makers of wind turbines, solar panels, rail, and electric cars together might be able to support a similar ecosystem. But why would the production of cars decline in a green economy, and why would this be a problem?

The Sunset of Petroleum

The main problem confronting the future of transportation is that oil will likely become more and more expensive and more and more difficult to extract. We have already seen the consequence of this situation in the Gulf of Mexico oil disaster,[21] and we are witnessing the unfolding of probably a bigger disaster in the development of tar sands in Canada.[22] Natural gas will probably never be able to replace oil as a source of transportation fuel, and we are also witnessing a potential slow-motion ecological disaster in the "fracking" of underground reservoirs of natural gas. Despite claims that fracking is a "game-changer," at best, fracking will make up for the loss of conventional natural gas drilling—and it is a more expensive process than before.[23] Ashley Dawson refers to the next phase of fossil fuel drilling as "extreme extraction."[24]

Another problem for the current transportation system is that it has never been shown that a good substitute exists for petroleum as utilized in the sector. Biofuels release more greenhouse gases than fossil fuels and have other devastating effects on ecosystems and agriculture.[25] Batteries, meanwhile, have never been shown to be able to store enough energy for the enormous demands of moving a multi-ton vehicle.[26] Thus, the future for large, fast-moving, long-distance personal vehicles looks grim.

The fact that transportation is based on oil is a cultural decision encouraged by economic self-interest. It is perfectly possible to have an all-electric transportation system[27] but this would involve profound changes to the spatial distribution of buildings in our society; in other words, the process of expanding sprawl would have to be reversed. It is beyond the bounds of this chapter to speculate on whether or how such a cultural shift will happen. However, besides the cultural changes such a shift would involve, an economic change likewise applies: we would not need nearly as many people or factories to make transportation machinery because a train-based society would be so much more efficient.

The Inefficiencies of the Automobile

The automobile is perhaps the most inefficient technology on the face of the earth to have achieved its stated purpose, specifically transportation of people and things (the same applies to trucks). First, vehicles are used only 4 percent of the time.[28] During the rest of the time, they use up parking space, thus wasting an enormous amount of space. Also, up to one-third of urban space is used for roads.[29]

A 4 percent rate of use means only one hour of use per day. Let's say that a good percentage of the population use their cars two hours per day, or even three.

This would lead to a usage rate of 8 or 12 percent—still very wasteful. Meanwhile, for a factory to be economical it generally must have a low "downtime"—ideally, machinery is used for at least sixteen hours per day, or even close to twenty-four hours. For the main transportation machinery of modern society to exemplify such low rates of usage is extremely wasteful.

The only thing more inefficient than a parked automobile is one that is being used. According to Amory Lovins, about 99 percent of the energy used to move an automobile is wasted; only 1 percent actually moves the person or things inside (about 70 to 75 percent is lost as heat by the engine while most of the rest is wasted in moving several tons of metal).[30] Moreover, most cars carry only one occupant, which is an inefficient method of transportation. But this is not the worst part: this form of transportation led to the deaths of 33,000 people in 2009, with more than 2 million people being injured that same year.

Jobs and the Modern Vehicle

So what would happen if all these inefficient vehicles were replaced by rail, plus some short-distance, small, slow electric cars? We would need considerably fewer factories to make transportation equipment. There are 877,000 jobs in the motor vehicle industry, 1.2 million in automobile dealerships, 800,000 in automotive repair, and 821,000 in gas stations.[31] So approximately 3 million people are directly engaged in manufacturing or servicing automobiles. Another 2 million jobs exist in the trucking and warehousing industries, alongside half a million in the aerospace industry and half a million in the airline industry.[32] Thus, a total of about 6 million jobs are associated with petroleum-based transport. Less vehicles would mean fewer jobs, although we cannot be sure exactly how many of these jobs will disappear until we see how technology for cars, trucks, and planes progresses.

Part of the explanation for the post-WWII boom was the enormous demand, and enormous workforce, created by this incredibly inefficient set of technologies. The automobiles (and truck and plane) together were panaceas for a society where production was not a problem but demand and jobs were. We could call it the era of "automobile Keynesianism."

The economist John Maynard Keynes, in the 1930s, offered a theoretical justification for creating more demand than was currently in force, if by creating that demand, the idle capacity of factories and offices could be utilized to employ a considerable number of people. At least in the short term, for Keynes, it did not matter if this meant digging holes and filling them again, although doing something useful was clearly better.[33] So throughout the post-war period, for instance, some economists have accused the Federal government of practicing "military Keynesianism." This would mean using the military budget to create demand that would not be there otherwise, and thus, at least in the short-term, improving the performance of the economy.[34] In 1999, workers in defense-related industry numbered 2.2 million, with a total of 6 million in military-related occupations.[35]

After WWII, there were fears that the economy would slip back into Depression without the stimulus of military spending. Road building taken to an epochal level by the Interstate Highway System as well as a push for car ownership led to "automobile Keynesianism". This then led to "sprawl Keynesianism" as governments at all levels encouraged single-family home ownership. Sprawl encouraged more economic activity, including waste-energy usage. According to an Environmental Protection Agency (EPA) report, moving from a single-family home to an apartment building can easily save 50 percent of home-energy use per person.[36]

Greater distances traveled in most suburbs has led to an ongoing need for more roads, for consumption of more oil to drive long distances, and for more effective maintenance of automobiles owing to the extra mileage. In addition, because most single-family homes are far from commercial areas it takes more roads, miles, and maintenance to drive to malls instead of walking or taking transit to local stores. Additionally, freight rail is at least four times more energy-efficient per ton than trucking.[37]

Jobs and Denser Cities and Towns

So a large construction and transportation work force has been kept busy building and maintaining a system that uses many times more resources than an electric-rail-based system. However, a shift from an energy-inefficient urban structure to a denser, more energy-efficient form of urban development would require a construction boom. It has been estimated that while 30 percent of the population would like to live in a walkable neighborhood, only 5 percent are able to do so.[38] Let's assume that 25 percent of U.S. households, or about 25 million households, would like to live in a comfortable apartment building in a walkable neighborhood, but one that would have to be constructed where none exist now. This would require use of "infill" where there is no town center currently, or beefing up the existing town and city centers. Let's assume that we would perform standardization on a 250-unit apartment building—meaning that we would need 100,000 such buildings, sprinkled throughout metropolitan areas, to accommodate 25 million households. If this endeavor cost $50 million per building in construction expenditures (assuming $200 per square foot, for 1,000 square foot apartments[39]), we would need a total of $5 trillion spread out over ten years, or $500 billion per year. At $50,000 per job, including the jobs needed to make and ship the relevant materials, the result would be 10 million jobs per year for ten years. And that's just to house 25 percent of the public in a denser environment; looking ahead, we might expect the following decade to yield a similar boom if the next 25 percent of households faced overwhelming financial pressures from higher and higher gas prices in ten years' time.

Pursuing this exercise a bit further, we can imagine that these new buildings would be constructed with energy efficiency and recycling in mind. For example, each building might have a very deep geothermal heat pump providing both heating and cooling.[40] Geothermal heat pumps use the constant temperature of the ground several feet down to cool buildings in the summer and warm them in winter. They use about 50 percent less electricity than an electric heating and air-conditioning system, depending on the area, and with solar panels they could even provide heating and cooling without using the grid, at least during the day.

The use of such technologies is increasing. The Chinese are encouraging the installation of geothermal heat pumps[41] as well as solar hot water heaters on roofs; in the latter case, millions of these low-cost systems have already been placed on roofs in China, and these are becoming popular worldwide.[42] Also, each new building could be constructed as a huge "passivhaus," the German design that cuts energy use by as much as 90 percent, while providing healthy ventilation.[43] However, the inclusion of passivhaus or other efficiency methods adds at least 10 percent to the price of a house, and builders have been reluctant to make housing more energy-efficient because, in general, buyers do not seriously consider efficiency during purchase. Accordingly, a number of programs in the United States and Europe have been designed to overcome this problem.[44]

When it comes to improved residential structures, the use of large apartment buildings offers another advantage in that they simplify recycling. Although rarely done now, it should be possible to fit apartment buildings with waste-composting systems and even dry toilet composting. Meanwhile, recycling of paper, plastic, and metals is already fairly advanced in some apartment buildings, and it should be an easy step to recycle appliances, furniture, and other consumer goods from buildings in this manner. A United States that was recycling at least 75 percent of its materials could employ over 2 million people.[45]

Sustainable Agriculture

As the supply of petroleum becomes more and more unreliable, eventually up to 80 percent of the population might live in a dense community in order to avoid the need to rely on long-distance driving of a personal automobile. Much of the remaining 20 percent of the population might be involved in agriculture or some other more rural-based economic activity. Agriculture since the 1920s has become extremely productive in terms of labor but not in terms of land, and certainly not in terms of energy, water, and soil. In fact, water, soil, and biodiversity are catastrophically declining because of modern agriculture,[46] although all civilizations have been required to be careful. If water and soil are considered capital, then modern agriculture may be considered to have a negative net effect on global wealth. Currently, agriculture is dependent on petroleum for its soil and ecosystem-destroying pesticide production, on natural gas for its water-befouling artificial fertilizer, and on petroleum for the operation of its farm machinery and the movement of food throughout its average 3,000 mile journey to the end consumer.[47]

On average, it seems that 15 percent more labor is required for organic farming methods than is required for conventional approaches.[48] Organic food now constitutes about 4 percent of the food market.[49] If, ideally, all food was grown organically, then we would theoretically require 15 percent more workers than the number of individuals currently employed, or about 270,000 more farmers. Much of the transition of agriculture would entail minimizing the need to transport food. This would mean growing and processing food within easy reach of walkable neighborhoods, that is, within cities and towns themselves or in nearby farm belts, and additionally using very little land, as in Biointensive Agriculture.[50]

If anywhere close to 80 percent of the population could reside in dense, walkable neighborhoods, with much of the rest of the population living near gardens and farms in the nearby countryside, then vast stretches of American ecosystems, such as the prairie, might be able to reassert themselves. Perhaps a substantial part of the population would be involved in managing a revived wilderness, or in the resulting eco-tourism, particularly if cheap, fast, and comfortable rail made it easy to visit various parts of the country—sustainably, of course.

Sustainable Manufacturing

Recycling jobs would also include transporting disposed goods to be used as inputs for factories, which in turn should be located close to urban areas and freight rail networks, all connected to high-power renewable-energy grids. Thousands of factories could be built close to urban areas during the reconstruction period. These factories could be equipped to produce goods that are easy to recycle or reuse and emit very little or no pollution.[51] Also, a complete redesign of industrial processes, particularly in the chemical industry,[52] would employ the talents of thousands of engineers while the construction of new factories with machinery made in the United States could lead to employment for millions of people.

The need to replace resources with machinery and to replace old industries and infrastructure with new industries and infrastructure implies that green manufacturing could lead a wave of technological change and sustainable growth.

The Government Must Lead a Green Manufacturing Renaissance

David Leonhardt of the *New York Times* writes that the United States "has not developed any major new industries that employ large and growing numbers of workers. There is no contemporary version of the 1870s railroads, the 1920s auto industry, or even the 1990s Internet sector. Total economic output over the last decade, as measured by the gross domestic product, has grown more slowly than in any 10-year period during the 1950s, '60s, '70s, '80s, or '90s."[53]

A green energy and transportation industry boom would be a perfect successor to Leonhardt's list. In each case Leonhardt enumerates, the government was critical to industry breakout. Abraham Lincoln's main economic platform was to encourage the development of the railways, and the transcontinental railroad was completed during his administration. The U.S. government gave railroads land on either side of their rail lines, giving them an economic incentive and built-in profit for developing rail. Later, the rise of the automobile would have been impossible had the government not virtually given much of the public space over to roads, an act only topped by the government's eventual building of the roads themselves. This would include, by the 1950s, one of the biggest infrastructure projects in human history, the Interstate Highway System.

Today, zoning regulations in much of the country make it virtually impossible to reach centers of employment or access critical services without a car.[54] In the case of the internet, the government developed the system until it became commercially viable[55] and has received virtually no return on its investment, except the taxes, if it can collect them from the Microsofts, Googles, Apples, Ciscos, and other companies that have gone on to make billions from the public investment.

One may argue that it is disingenuous for critics to now talk about unfair subsidies to the green energy sector when one considers historical government assistance to many other industries. Even the oil industry could not have become the dominant force it is today without the aforementioned actions of the government in support of the road and highway system. In previous eras, as Leonhardt's list makes clear, the United States was on the cutting edge, doing much of the initial work to advance new technology, and its leadership in the modern context extended to high-speed rail and wind and solar technology. Yet now their development is being led by the Asians and Europeans. There is nothing wrong with other countries pursuing useful technologies, but the critical question is, why hasn't the United States kept up?

The Effect of the Military on Manufacturing

In the United States, the main governmental driver of manufacturing is the military. The internet was actually developed with funds from the research branch of the military, the Advanced Research Projects Agency (ARPA). Airplanes were heavily subsidized by the military, and the Interstate Highway System was partially justified based on its ability to transport tanks across the country. However, this emphasis on military production has over time warped the U.S. manufacturing sector in many ways.

As Seymour Melman sought to show in several books, the military–industrial complex, or "permanent war economy," as he called it,[56] has several unfortunate effects on manufacturing. First, a large percentage of scientists and engineers are soaked up by military production; generally, the pay is higher for military work, and thus, other firms are at a disadvantage in competing for the best engineering talent.[57] Second, the trillions spent to date on the military could have been better spent on rebuilding the infrastructure and manufacturing sector as a whole. But the third and probably the worst problem identified by Melman is the loss of competence in civilian manufacturing that accompanies a focus on military production.[58]

During the Cold War, we heard a steady drumbeat of criticism in the United States that the Soviet Union was less efficient because of central planning. The Soviet system output shoddy products and less of them, it was asserted, because the competitive discipline of the market was lacking. At the same time, many of these critics (not all) were advocating for larger and larger military budgets in the United States. But the military is, just like the Soviet system, itself a centrally planned economy, even if it is a smaller part. The same inefficiencies observed in the Soviet system also occur in the American military industrial complex—that is, military equipment is much too expensive, takes too long to make, and breaks down much more than it should.[59] This is partly because the military operates on a "cost-plus" system, that is, they can charge the government for any cost of building the equipment and then simply tack on a certain percentage as profit. The more expensive the output, the more profit there is to be made, and thus, there is an incentive to make equipment more and more costly.

The tragedy for the wider society is that once managers and engineers become used to a business culture in which cost is something to be maximized, not minimized, it becomes very difficult for a military equipment manufacturer or its managers and engineers to shift to a cost-minimizing culture. Thus, a significant percentage of the manufacturing economy, meaning those involved in military work, warp the industrial competence of much of the rest of the manufacturing economy. The U.S. Department of Defense procured $134 billion worth of manufactured goods in 2010[60] versus a manufacturing value-added of $1.6 trillion in 2009.[61]

The Military and a Green Economy

The dynamics explored above pose several consequences for a move to a green energy economy. First, the interest of the Department of Defense in becoming "green," for instance by using solar panels instead of incurring very steep costs from trucking in oil,[62] could prove to be a double-edged sword for the United States. On the one hand, money spent by the Pentagon will constitute an important market for nascent solar and wind manufacturers; on the other hand, these same manufacturers will get used to the "cost-plus" nature of Pentagon contracting. They will either decide to concentrate on the higher and less risky profits of military contracting, thus ceding the civilian market to other countries, or they will lose the competence to produce cost-minimized products in the civilian economy, or both.

Second, green manufacturers for the civilian economy face the disadvantage that much of the manufacturing ecosystem is devoted to cost-maximization, and thus, they will not be able to take advantage of the rich pool of subcontractors that the other developed countries maintain. In the United States, either many suppliers have gone out of business and are not available, or they have been pulled into the orbit of military production, thus making them effectively unavailable as well.

Third, there is the wider problem that much of the military's claim to its hold over a significant amount of government resources is that the military protects our supplies of oil.[63] The less we need oil, the less we need the military. As Chuck Spinney has written, the military can be viewed as a vast network devoted to obtaining as much government revenue as possible.[64]

Positive Lessons for a Green Economy

Despite these problems, two major lessons can be gleaned for green energy advocates when considering the success of the military–industrial complex. First, perhaps the greatest weapon in the Pentagon's arsenal is not its nuclear weapons or aircraft carriers, but its carefully orchestrated placement of military factories and bases throughout the United States which engenders support for the military from the Representatives and Senators who are endowed with these job-creating assets. Politicians are perfectly willing to accept "socialism," that is, government control of economic activity, if it brings a predictable supply of high-paying jobs. The lesson for a green economy is that a similar network could be created for wind, solar, high-speed rail, and other green technologies. That is, factories for producing solar panels, wind turbines, rail equipment, and even materials to be used in energy self-sufficient apartment buildings could be distributed throughout the country with an eye to creating a self-sustaining political consensus within the Congress. In other words, the United States could build an "infrastructure–industrial complex."

But how would this strategy of institutionalizing the "political will" for a green infrastructure be implemented? First, a program of economic reconstruction would require that all equipment and products bought with government financing would have to be made in the United States. Second, an overall plan of action would have to be designed for a time horizon of at least five years, and preferably, ten to twenty years. Then, the location of the factories used to create the wind, solar, or rail equipment could be proposed.

The second lesson of the military economy for green energy advocates is that it might be possible to convert military factories into green energy equipment factories (what Seymour Melman called "economic conversion"). That is, we can cut the military budget in order to serve much more pressing civilian needs but at the same time ensure that individuals dependent on military production for their livelihoods would retain good jobs. Through such efforts the economy's conversion—from one that is militarized, to one that is civilianized—can potentially gain significant and widespread support.[65] This concept of conversion could be extended to the fossil fuel and automobile industries as well.

Avoiding the Pitfalls of Government Planning

But if a green economy was at least partially planned, if there was an infrastructure–industrial complex, or a green economy–industrial complex, what would prevent the appearance of the same inefficiencies as demonstrated by the military or Soviet systems?

First, a continental system of reconstruction would need to be planned in a decentralized manner, that is, local and state governments would have to be intimately involved in the planning. Since local governments are more familiar with the needs of their communities and constituents than the Federal government, it would make sense to provide them with significant input into the process, including the ability to make the case for siting factories. With more eyes and hands involved in the planning process more transparency could be achieved. Ideally, the Federal government would present the broadest design plans possible, with the local governments filling in as much as possible. Second, an infrastructure–industrial system would not be cost-plus; rather, the contracts would be for a specific amount with no room to increase the cost. Third, there would be no need to "sole-source" the equipment, so that more than one company would provide the trains, wind turbines, and solar panels. In this way, if one company went out of business, or did not come through with its order, or otherwise violated its contract, other contractors could be engaged. Fourth, since the general population would be using the equipment or the output of the equipment, reliability stands to become a much larger factor than that in the military situation. Fifth, while some inefficiencies will remain—inefficiency and even some corruption are part of any human enterprise—that does not mean, however, that inefficiency and corruption should not be minimized. And transparency, more broadly in the current context, would be a very important part of a program of economic reconstruction.

Why Planning is Necessary

While several approaches may be pursued to decrease the inefficiencies which are a part of national planning, there are also ways in which national planning is much more efficient than the ad hoc development provided by the market. The national government can plan holistically and in the long term which the market cannot. For example, the Interstate Highway System was designed as a whole, not in pieces—and with a great deal of local input.[66] Similarly, design of a high-speed rail system or revived medium-speed rail could be planned by the Federal government, along with input from the state and local governments, implemented locally. In fact, a high-speed rail network could run alongside much of the Interstate Highway System and part of the interstate could be used for slower trains, as J. H. Crawford suggests.[67]

A national wind system would probably benefit the most from a national perspective, although that is not how the wind system is currently developing, since there is no Federal grand plan. Wind power becomes more reliable, as more wind turbines are available and are distributed in different environments. To put it most simply, since wind is always blowing somewhere, if placement of wind turbines is appropriate, wind will always be available for generating wind power.[68]

By designing and financing a long-term, continental plan for wind, the Federal government could guarantee a market for firms through means that would be much more effective than the current preferred method, a tax credit. If a company received a ten-year contract to build a certain number of wind turbines, then the company and its suppliers would be guaranteed a stable market. Also, by contracting for a large amount of wind turbines at the same time, economies of scale could be achieved.

Another advantage to a national wind plan would be to site the wind farms, not only to ensure that wind power is being continuously generated but also to avoid siting problems that occur in more localized situations. In a number of situations, local communities have expressed an interest in wind power but the placement of wind farms close to populated areas, or to the flight paths of birds and bats, or to forest stands, would cause environmental damage.[69] In contrast, if turbines are concentrated in the windiest parts of the Great Plains and Midwest, for instance, away from populated areas, many of these problems are resolved and local areas can have clean wind energy without nearby siting issues. Meanwhile, some companies are using more efficient wind machinery that requires rare earth metals; a national plan could require that these be used sparingly.[70] However, materials should not be a constraint in building wind turbines.[71]

National planning for a green energy system would ideally take place at an even higher level than a national wind system. The size of the wind system would very much depend on the characteristics of the rest of the system, for example, how much solar photovoltaic energy is used, while the design of an energy infrastructure would also depend on what kind of rail and electric car systems are envisioned. Local photovoltaic, ground source heat pump, and other decentralized electricity sources would lead to a smaller wind system but a national rail system, including local transit plus electric cars and trucks, would lead to additional wind energy needs.

A national energy strategy would have to include the reconstruction of the national electric grid.[72] Currently, electricity is moved from power plants to home via an electricity grid, that is, a network of wires that passes across the country. However, this network grew in a very ad hoc way without planning at the national level. In addition, the grid has not been properly maintained, partly because private utilities do not see much profit in doing so. It is even possible that private utilities would not mind the government taking over the construction and maintenance of the grid.[73] The advantage here is that the government could create a national design for an updated, much more efficient grid, and run and maintain it, thus providing a basic service for the entire country. To accomplish this goal perhaps the government could simply buy the grid from utilities.

We can look at the economy from an even higher vantage point and consider the benefits of planning the energy, transportation, and urban infrastructures simultaneously. If we plan to achieve a much smaller (or even zero) use of petroleum, then we need to reconfigure the transportation system to be electricity-based, with enough density in town and city centers to realize a train-centered transportation system. We would have to plan to build a large number of structures in these towns and cities. We would also need to move manufacturing and food production closer to the denser population centers. The Federal government could provide broad guidelines for a particular region for transportation, energy, urban layout, and even agriculture, as well as financing. Localities would actually design these town and city centers and the transportation, energy, and production configurations specific to these centers.

Planning the transformation of a significant part of the national infrastructure in no way implies central planning on the order of the Soviet model. The latter was in fact designed as a means to funnel most of the country's output into the military sector, and thereby encompassed the bulk of the economy.[74]

The larger the green economy, the greater the manufacturing capacity needed for the various green economy machinery. Moreover, as this green machinery market expands the system of suppliers that form the base of any manufacturing system will also expand. Currently, efforts are so scattered that few domestic manufacturers are convinced that there will be a long-term market for them.

Jonathan M. Feldman has written on the reasons for the anemic state of the domestic rail industry in the United States, and possible methods to revive it. A key finding is that the weakest element in the industry is the lack of a stable, long-term market which must be accompanied by a long-term relationship with local and national governments and trade unions.[75]

Currently, corporate America is sitting on almost $2 trillion of funds because firms do not perceive any profitable ways to invest their money.[76] And there may not be, at least without some larger national push—we are in a situation akin to standing at the bank of a river knowing that we will enjoy a better life if we can only get across the river; but we have no boat. A national program of economic reconstruction, financed by the Federal government, could be that boat.

The Market Can't Create a Green Economy on its Own

John Maynard Keynes and many others have pointed out that the private market can remain stuck at a suboptimal level unless the government gives the economy a "kick." Thus, not only was government spending necessary to pull the United States out of the Great Depression in the 1930s, but government financing, which began in Franklin D. Roosevelt's administration, was also necessary to kick-start the entire real estate financing system which led to home ownership for tens of millions of people. Before the government intervened in this market, most financing was for five years for a home, and repossession was common.[77]

In the same way, the government will be required to simultaneously create various pieces of the green economy in the early twenty-first century. Manufacturers need to know that a long-term market exists for their offerings, but currently small rail, wind, and solar markets offer little incentive. For instance, since the construction of wind farms is piecemeal at present, it cannot be as effective as a national system of coordinated development, so wind does not look as promising as it should. The same applies for a reconstruction of the national grid, high-speed rail, other electric rail systems, and solar manufacturing.

So far, however, only the Chinese have been willing to put forward the required investment.[78] The financial sector is not capable, or at least willing, to make a multi-trillion dollar investment in something new. They demonstrated a willingness to enter the real estate market only after the government intervened, first by creating the market, then by deregulating it. Only the government boasts the capability for the long-term planning and financing that is necessary to get us over the river and to a green economy. Once this new economy is constructed the private market will feel very comfortable when making shorter-term investments.

A Program for Creating a Green Energy Economy

Substantial employment and stimulative effects could ensue from a stimulus strategy for green manufacturing. For instance, let's start by looking more closely at a national wind system.

Interstate Wind System

Let's first assume that the entire supply of electricity in the United States was generated from wind, and just to make things easy, let's assume that the demand for electricity does not go up in the next two decades. The conventional estimate for the age at which a wind turbine needs replacement is twenty years. Let's assume that it would take twenty years to increase the percentage of electricity generated from wind, that is, from 1.9 percent in 2009[79] to 100 percent, say in 2034. Then we would need to construct 5 percent of a 100 percent national wind system every year, until the entire system was built by, say, 2032. After 2032, we would still indefinitely need to replace 5 percent of wind turbines each year.

The United States uses about 4,000 billion kilowatt hours (kWh) of electricity.[80] This huge number can be converted in many different ways: 4 million gigawatt hours (GWh), or 4,000 terawatt hours (TWh), or 4 petawatts. Here, we will use TWh because that is a concise way to keep track of how much electricity is used and generated.

Electricity sources are usually rated according to their hourly capacity to generate electricity. To make matters complicated, each hour for each source of electricity may generate a different amount of electricity, depending, in the case of wind, on how much wind is blowing and the size of the turbine. In 2009, wind generated 73.886 TWh[81] with a capacity of 34.296 gigawatts (GW),[82] which is a capacity factor of 24.5, that is, about one-quarter of the maximum capacity of wind is being used. The National Renewable Energy Laboratory (NREL) estimates that the average capacity factor for new wind turbines is about 39 percent.[83] Another advantage of Federal planning would be that turbine farms would be located in the best areas in terms of capacity usage, and the larger the turbine, the better the capacity factor.[84] But let's assume a middle ground between the current overall capacity factor and the technological best-case, and for convenience, let's say that we can figure on a 33 percent capacity factor.

So, if we take the total hours generated, 4,000 TWh, we know that if we wanted it all to come from wind, we would need a system that has the capacity to generate 4,000 × 3 = 12,000 TWh, so we would need an economic system that would have the capacity of generating 12,000 TWh. Divide this by the number of hours in a year, and we find that we need about 1,370 GW of wind-turbine capacity. Thus, while using *terawatt hours* as the main measure for actual output, it may be easier for the reader to use *gigawatts* when considering capacity.

Now, adding wind capacity is not the same as adding coal or natural gas plants because fossil fuel plants are running about 90 percent of the time, but wind may die down in one area completely. People do not want to deal with "intermittent" sources of power; they quite understandably want power all the time. According to engineering researchers[85] the intermittency problem is overcome by adding wind turbines over a larger area. Eventually if wind turbines are properly spaced all across the continent it should be possible to create a wind-based electrical system in which enough wind is blowing in most locations all the time so that no one is deprived of electricity.

Most studies of national wind power systems do not assume a 100 percent wind-based system. Gar Lipow[86] argues that with the addition of enough battery storage capacity, and perhaps adding more to the wind system than is strictly necessary, it should be fairly straightforward to construct an all-renewable system. Lipow also points out that some electricity is lost in the process of transmission, so—returning to our earlier calculations—we may add about 10 percent for transmission loss which gives us a round number of 1,500 GW for a built-up national wind system. For estimating the effect of a wind-based economy on the structure of employment we may use this figure even though further research is needed.

NREL estimates that some 4,300 full-time jobs are created per gigawatt of capacity of wind power.[87] In addition, according to a Renewable Energy Policy Project (REPP) report, "70 percent of the potential job creation is in manufacturing the components, 17 percent in the installation, and 13 percent in operations and maintenance."[88] The REPP study finds that there are 3,000 manufacturing jobs for every $1 billion in investment which the study's authors translate into 1 GW of capacity. Another way to confirm wind power employment levels is to look at the operations of Vestas, the largest wind turbine manufacturer in the world, based in Denmark. They have 21,000 employees, and in 2011 it was estimated that they will produce 6 GW of capacity,[89] or about 3,500 employees per gigawatt, close to REPP's estimate. So if the United States builds 1,500 GW of capacity, spread out over twenty years, then it would have to build 75 GW per year, translating to approximately 225,000 manufacturing jobs per year. This level of employment would be indefinite, as after twenty years the wind turbines would need to be replaced. The extra 1,300 full-time jobs per gigawatt would be in installation and operations and maintenance. Assuming for every gigawatt some 700 jobs in installation, which would stay constant, we would have 52,000 jobs in installation; however, the operations and maintenance would increase until the full 1,500 GW was installed, when we would need 900,000 permanent workers in these service occupations at the end of twenty years.

These estimates do not include the steel production needed to create wind turbines, which is a relatively low percentage of the total steel output. The United States alone produced about 80 million tons of raw steel in 2010, and the world total was 1,413 million tonnes.[90] NREL estimates a need for 114,000 tons of steel per GW capacity for wind;[91] if we need to create 75 GW per year, we need more than 8 million tons of steel per year which is only 10 percent of the US total. The steel industry claimed approximately 159,000 workers in 2008, so we would add only about 16,000 workers. Meanwhile, a considerable amount of fiberglass and concrete is used in wind turbines, but these also do not create any great pressure on resources, labor, or land.[92]

Estimates of the cost of a kilowatt (kW) of capacity for wind vary from $1,500 to $2,000.[93] Assuming $2,000 per kW, and 75,000,000 kW built per year, the required budget would be $150 billion per year, hardly a huge amount by national standards. If we assume 3-megawatt (MW) turbines, which are large in scale but not particularly cutting edge technologically speaking, we would need to construct 25,000 wind turbines per year for a total of 500,000 by the end of the twenty-year period. The current US average turbine size is 1.79 MW[94]; if we assume the use of 1.5 MW turbines, we would need to construct about 1 million in twenty years.

Advantages of Federal Ownership

It would be best if the Federal government financed and designed the system; ideally, the Federal government should also own the system for a few reasons.

First, as argued previously, it is much better if wind is sited according to a master plan from a national perspective in order to minimize the problem of intermittence. Only a national authority such as the Federal government can serve this role. Second, the Federal government can finance the construction and operation of a national wind system either with very low interest rates, or even out of general funds. If this system was funded without loans, the resulting electricity would

be so cheap that the government could offer a set annual amount of electricity to each person for a very low price, or even for free, offering American citizens and businesses a higher standard of living. In order to avoid the problem of Jevons paradox,[95] that is, greater use of electricity owing to its lower cost, all electricity above a base amount could be charged at the full price of added capacity. Third, the Federal government would not need the expense of providing a return to investors which in the utility industry is generally around 10 percent.[96] A national wind system could thus be built at a cheaper rate by the government (albeit perhaps through the use of private contractors). Fourth, a wind system requires a rebuilt national grid. According to the Electric Power Research Institute, an upgraded smart grid would require between $338 billion and $476 billion.[97] Let's round that up to $500 billion. If we assume a twenty-year construction period, and $25 billion per year invested, and an average of $50,000 per job, then we could have 500,000 jobs per year upgrading the grid. In addition, a national set of large battery systems could be integrated into the network, providing another layer of protection against intermittency problems. Lipow estimates $1,000 per kW capacity,[98] or $1.2 trillion over, say, twenty years, or an extra $60 billion per year to add in a battery storage system. If this yielded 10,000 jobs per $1 billion invested (high capital manufacturing generally yields fewer jobs), we would have another 600,000 jobs per year making and installing batteries.

Jobs and a Green Economy

Construction of a national wind and grid system supports many other sectors. For instance, rail, transit, solar energy, heating and cooling, electric cars, and electricity for transportation all benefit from their integration into a national wind and grid system. Similar calculations can be performed for the other sectors, and these calculations are presented in Table 2 to provide an understanding of the potential and scope of a green manufacturing stimulus strategy. Other chapters in this volume also cover job creation (see Wendling and Bezdek, Chapter 4).

The calculations assume a timeframe of twenty years per project, where the total jobs per year indicate the number of jobs required after the completion of the twenty-year buildup program. Thus, the United States could achieve approximately 24 million middle-class jobs by the time the country has finished the construction of a green economy. More than five million could be employed in manufacturing, moving the nation almost half the way back to a full manufacturing economy.

This renewable energy part of this program would replace more than 1 million jobs lost in the fossil fuel industry. The construction component would also replace about half of 7.2 million jobs in the construction industry employed in expanding sprawl.[99] The recycling program would make up for more than 700,000 jobs lost in mining.[100] The various rail programs and electric car manufacturing would

Table 2
Summary of Program for Creating a Green Energy Economy

Industry	Total jobs per year	Manufacturing jobs per year	Cost per year/ billions
Wind 4,000 TWh	1,130,000	225,000	150
New electric grid with battery storage	1,100,000	300,00	85
100,000 250-unit apartment buildings	10,000,000	2,500,000	500
100% Organic agriculture	270,000	0	N/A
Recycling	2,000,000	200,000	100
17,000 mile high-speed rail system	600,000	90,000	301
High speed rail operations	1,000,000	0	0
Electric freight train system	500,000	125,000	25
Transit capital	300,000	300,000	60
Transit operating	1,300,000	0	200
Geothermal heat pumps	1,000,000	250,000	50
Solar 1,000 TWh	2,500,000	600,000	150
Weatherizing	1,000,000	250,000	25
Electric car	1,000,000	500,000	0
Total	**23,700,000**	**5,040,000**	**1,375**

replace most of the 6 million jobs that were counted previously in the vehicle manufacturing and services industries, most of which would probably disappear in a green economy. In other words, while approximately 10 million jobs would be lost, some 14 million more jobs would be created in a green economy, with a stronger manufacturing base than in the current US economy. These new green jobs will have indirect employment effects that are equivalent to or greater than the benefits of direct jobs; in other words, about 20 million extra jobs could be created as well through a green economy (because of the multiplier effect[101]).

Conclusion

In order to create a thriving national economy and a strong middle class, the United States needs to re-establish its manufacturing base. By engaging in a program of economic reconstruction as laid out in this chapter—transforming the transportation, energy, building, urban, manufacturing, and agricultural systems—the country creates a golden opportunity to fulfill these long-term goals. However, the Federal government, in concert with local and state governments, will have

to engage in a minimum twenty-year construction program. The investment in this program should be close to $1 trillion (or more) in order to capture the benefits of mutually beneficial programs. Creation of an "infrastructure–industrial complex" to at least partially replace the military–industrial complex of the past decades would go far in bringing about the political will for such a transformation.

At the same time, by virtually eliminating the use of fossil fuels, by conserving our water, soil, and ecosystems, and by re-using our resources instead of throwing them away, we can prevent the ecological catastrophes of global warming, resource depletion, and ecosystem destruction.

We face a difficult set of challenges, both economic and ecological. Fortunately, we have the technologies, the resources, and the human talent to meet those challenges. Ultimately, ecological sustainability is the same as economic sustainability. The earth, the machine, and our species can co-exist peacefully, if we so choose.

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