Self-Reliant Cities

by David Morris (originally published 1982)

Foreword
October 2008

If *Self-Reliant Cities* is a snapshot of a certain historical moment, why then have we decided to reissue it more than a quarter of century after its original publication?

Because we deeply believe the energy and climate crises must ultimately be solved at the local level and cities can learn much from the efforts of their predecessors. For it is at the local level that the proverbial rubber meets the road, where theory becomes practice, where policy must be implemented.

Cities are the locus of authority closest to the people. Cities have significant authority over land use and building standards, areas that significantly influence energy consumption, and in the near future, energy production. And urban areas are home to more than two thirds of Americans and half the world's population.

Self-Reliant Cities was published by Sierra Club Books in 1982. As we would later discover, the country was at the tail end of our first national effort to eliminate our growing dependence on imported oil (33% in 1974).

That national effort was catalyzed by an embargo imposed by the newly formed Organization of the Petroleum Exporting Countries (OPEC) on oil exports to countries supporting Israel during the 1973 Yom Kippur War. The Arab nations reduced their oil production by some 5 million barrels per day, resulting in a 7 percent drop in world oil production. Oil prices, stable from 1958 to 1970 at about $3 per barrel, suddenly quadrupled to over $12 per barrel. More importantly, shortages resulted in lines at gas stations that snaked around the block. Many jurisdictions required drivers to purchase gasoline on alternative days, depending on whether their license plates ended with an odd or even number.

Washington reacted by launching Project Independence. Congress enacted a series of new energy laws, mandating energy efficiency upgrades in cars and major appliances, abolishing the utilities' monopoly on the generation of electricity and requiring utilities to purchase power from small on-site and independently owned power plants. Incentives were offered for renewable fuels. The R&D budget for renewable energy and energy efficiency exploded. Congress established a national Solar Energy Research Institute (SERI).

Even before the oil embargo, the first Earth Day in 1970 marked the beginning of mass grassroots environmental activism. An explosion of collective activism demanded more rigorous environmental policies while at the same time an equally large explosion of individual activism occurred in the form of tinkerers, inventors and entrepreneurs experimenting with new building designs and environmentally benign energy technologies.

The guiding philosophy of these movements was summed up by the title of Fritz Schumacher's best selling and hugely influential 1973 book: *Small Is Beautiful*.

My own organization, the Institute for Local Self-Reliance was born in 1974. The focus then and now has been on building equitable and responsible humanly scaled economies and political systems.

For many, the shift to renewable fuels also portended a more decentralized energy system. Joseph Lindmayer, inventor of the first high efficiency solar cell used by orbiting satellites in the 1960s and the owner of the first factory producing solar cells for terrestrial applications, opened in 1974, made this point when he testified to Congress in 1979. He noted that of the thousands of letters he had received from people who wanted to buy solar cells, few justified their interest largely on environmental grounds. Most "wanted to become more independent from the utility company".

The combination of the Iranian revolution in 1979 and the outbreak of the Iraq-Iran War in 1980 produced a second and even more severe oil shock. Prices more than doubled, from $14 a barrel in 1978 to $35 in 1981($93 in 2008 dollars). In 1980, Congress approved a massive appropriations bill offering incentives for a wide range of alternative liquid fuels and renewable energy technologies.

While the federal government acted, much of the action occurred at lower levels of government. They became, in the famous words of Supreme Court Justice Louis Brandeis, "laboratories of democracy", responding to their citizens' desire for energy independence by developing innovative energy policies and structures. Before Congress directed the federal Department of Energy to establish national appliance efficiency standards, California had such standards in place. In 1981, Minnesota enacted the nation's first net metering law to enable on-site electricity generation. Oceanside, California launched the first solar collector (hot water) leasing program. To enable rooftop solar, many cities prohibited new houses from casting shadows on their neighbors' roofs. Saint Paul, Minnesota began to design, and then construct the nation's largest hot water district heating system.(In the 1990s it would add a cooling component.)

Using the utilities' own electricity models, Zack Willey and Arjun Makhijani proved that investments in energy efficiency were more economical than investments in new power plants. Their argument inspired the California Public Utilities Commission to redesign utility regulatory policies to encourage a least cost planning process that emphasized efficiency improvements.

Michael and Judy Corbett persuaded Davis, California to rewrite its local planning and building ordinances to enable their new housing subdivision that contained passive solar heating, natural drainage, narrow streets, and other resource saving features.

In 1978, following a catastrophic 200-year flood, the Village of Soldiers Grove, Wisconsin voted to relocate to higher ground and build a more sustainable community. Its citizens conducted a microclimate analysis to detect wind and sunlight patterns, and used earth berming and landscaping to shield the new town from winter winds. They required new buildings to be twice as energy efficient as state law required at the time and passed the nation's first ordinance requiring that new non-residential buildings generate at least half their heating energy from solar energy systems.

While the nation looked to reduce its dependence on oil, it was planning to become more dependent on uranium. That era was the high point of nuclear energy, a technology 100 percent subsidized by the federal government in its R&D and early commercialization stages. Planners envisioned 2,000 nuclear reactors generating the majority of the nation's electrical energy. But the building spree had hardly gotten off the ground when a near meltdown at Three Mile Island in the spring of 1979 stopped the industry in its tracks and added fuel to the marriage of alternative energy and environmental activism.

Self-Reliant Cities was published just as events conspired to end this first national effort at national and local energy independence. One event was political, the election of Ronald Reagan, whose campaign was summed up by his declaration, "Government is the problem, not the solution". Upon gaining the White House, Republicans immediately tried to overturn virtually all major energy legislation enacted in the 1970s. They were thwarted by the Democrat-controlled House of Representatives. The Executive Branch, however, was able to block the implementation of many of the energy-related Congressional initiatives.

The Department of Energy refused to enact the higher appliance efficiency standards mandated by Congress half a dozen years earlier. Funding for renewables and energy efficiency plummeted, including funding for state and local initiatives. In a symbolically contemptuous gesture, one of Ronald Reagan's first acts was to remove the solar panels installed at the White House by Jimmy Carter.

The other event that occurred, also in 1981, was economic--the worst economic recession in the US since the early 1930s. Precipitated by a severe tightening of credit engineered by the Federal Reserve to dampen inflation largely caused by rapid increases in oil prices, a near depression in the United States spawned the first contraction in worldwide trade since 1931. As economies shriveled, the price of oil plummeted from a high of $36 barrel when Ronald Reagan took office in January 1981 to below $10 per barrel in 1986.

The country entered what in retrospect might be viewed as an historical parenthesis, when energy independence, either at the national or state or local level, was no longer on the political agenda of either party, a parenthesis that ended only with the US intervention in Iraq in 1989, the subsequent spike in oil prices and growing awareness of the intimate connection between oil and terrorism.

The embryonic renewable energy and efficiency industries survived largely as a result of state initiatives and entrepreneurial innovation, but forward progress was minimal. Many states followed California's example and required natural gas and electric utilities to invest in energy efficiency. At its peak in the early 1990s, several billion dollars a year were channeled into improving efficiency by the nation's utilities. To encourage renewable electricity, California required its utilities to pay a premium price (10 cents per kWh) on a long term (10 year) power purchase contract. This, coupled with the incentives remaining in the early 1980s, spurred the beginnings of the modern, large scaled, US wind energy industry.

The ethanol industry survived the aggressive effort by oil companies to eliminate a potential competitor by selling as much as two thirds of its product through farmer cooperative owned gas stations, although the collapse in the price of oil led to the bankruptcy of some 90 percent of the very small ethanol plants built in the early 1980s. In the 1990s, farmer-owned biorefineries reinvigorated the industry and by 2000, had become the new ownership model.

The solar cell industry continued to grow because, alone of all renewable technologies, it was competitive without incentives for certain applications because of its reliability and maintenance-free operation. A market existed for solar cells at remote non-grid connected sites where the alternative, maintaining and refueling on-site diesel generators. was too costly or where the cost of laying new distribution lines was prohibitive.

The Gulf War inspired Congress to revive incentives for renewable electricity in 1992. These were useful, but the renewable electricity industry didn't take off until states began to mandate its use. Between 1995 and 2005, the vast majority of wind electricity was generated as a result of these state mandates. Meanwhile, more than half of all states imitated Minnesota and enacted net metering standards in an attempt to enable on-site renewable electricity generation.

2005 marked a new turning point in America's, and the world's energy future. The Iraq War had already driven up gasoline prices when hurricane Katrina slogged through the Gulf of Mexico and slammed into New Orleans and the Mexican Gulf removing a significant amount of US refinery and off shore drilling capacity. Gasoline prices rose above $3 per gallon. Congress enacted a major energy act, the first since 1992. One major impact of that law resulted from a provision that did not make it into the final bill: immunity from liability for companies selling MTBE.

The fossil fueled-derived MTBE, the nation's best selling octane enhancer and clean air additive was introduced on a large scale in the early 1990s. By the end of that decade, it was found to be contaminating ground water. More than half a dozen states passed legislation phasing out its use and dozens of cities and counties sued MTBE producers for the multi-billion dollar clean-ups of their water supply. Without Congressional immunity, oil companies precipitously phased out MTBE in early 2006, prompting a rush to substitute ethanol for MTBE, which led to sky-high ethanol profits, and the beginning of a massive investment in biofuels by Wall Street.

Which brings us to 2008. The unprecedented (in absolute dollars) increase in oil prices from 2007 to 2008 has again moved energy to the very top of our political priorities. But this time the context of the debate has changed.

One change is that many view this run-up in oil prices as a more enduring phenomenon than those of the 1970s or early 1990s because of the massive increase in oil consumption by China and the modest increases in supply.

The second change is the emergence of an issue that was not on the table during the crises of the 1970s: global warming. Most industrial and even a significant number of industrializing nations recognize this is a real and urgent phenomenon that can be ameliorated only by rapidly substituting low and no carbon fuels for coal and oil.

Finally, and the most important change of all, is that the new crisis comes at a time when the renewable energy and energy efficiency industries have reached near-maturity. In the 1970s the world literally had to invent new technologies, new evaluation methodologies, new approaches to construction. Industry had to develop a national distribution and maintenance system, create performance warrantees backed by insurance companies, and create mechanisms to attract billions of dollars in new investment.

In 2008, all of these systems are in place. More than $15 billion may be invested in wind turbines this year in the United States alone. Sales of solar cells are doubling every 3 years. The federal government has mandated a six-fold increase in biofuels by 2022. Ninety percent of the expansion after 2009 coming from non-food crops.

Thus in 2008, we do not need to invent a new industry. We need to move existing industries that still play only a bit role in the energy sector to center stage. And unlike in the 1970s, 1980s and 1990s, that very industry is increasingly demonstrating the political clout to be a major factor in accelerating this development.

We hope *Self-Reliant Cities* can inform the work of the current generation of energy and environmental activists at the local and state levels. The renewed interest in the local in many sectors has led to a re-examination of the authority of local governments.

The first half of *Self-Reliant Cities* discusses the century-long struggle by cities to gain autonomy and authority from state governments and create their own planning and service delivery capacities.

Cities, and counties have real power--financial, regulatory, purchasing. Collectively, local governments borrow tens of billions of dollars each year, largely to build or rebuild urban infrastructure. Even small cities can, and have, undertaken multi million dollar projects. In most states, cities dictate the patterns of land use within their borders, and the structure of their built environment, an important fact, given that almost half our energy can be attributed to buildings. Cities have great influence over local transportation systems. They own water and sewage and road networks. Over 2,000 own their electric distribution systems. Many of these also own power plants.

All of these expressions of municipal power will be important as we try to transform our energy future.

As *Self-Reliant Cities* discusses, communities can and should play a crucial role in designing our energy future because localities by definition have a self-interest in a decentralized energy future.

As we move from fossil fuels to renewable fuels, we move from a reliance on resources highly concentrated in just a few locations to fuels literally available everywhere. And because they can be found everywhere, renewable fuels lend themselves to being harvested near the ultimate customer.

However, just because renewable fuels fall everywhere does not mean they will inevitably be harvested everywhere. That will happen only by the active and aggressive involvement of local governments. We suspect that this will happen if only because the prospect of becoming energy producers as well as energy consumers will galvanize their citizens and businesses to demand that their local governments encourage and enable that opportunity.

Currently we are witnessing a largely unforeseen emergence of centralized forms of renewable energy(e.g. large scale remote wind and concentrated remote solar). Some alternative energy advocates note that there is more solar energy in Nevada than in California and higher speed winds in North Dakota than in Illinois and therefore it is better to produce solar electricity in Nevada and wind energy in North Dakota. Some point out that a solar farm in Nevada in a square a little over 90 miles on a side could generate enough electricity to meet all US needs and wind farms on only a fraction of North Dakota could satisfy 25 percent of all US electricity consumption.

To encourage this vision of a centralized renewable electricity future, the federal agenda has adopted as perhaps its number one priority the construction of tens of thousands of miles of high voltage transmission lines to deliver huge quantities of wind energy generated in the spine of the country running from the Dakotas to Texas, to large coastal cities and to deliver huge quantities of solar power from the southwest to California. With the likely protest of citizens, states and communities, the time line to implement such a centralized energy vision could be extended.

When *Self-Reliant Cities* was published, there was little sense that renewables could lend themselves to centralization, except for the proposal by NASA for a solar power satellite system. The SPS would be the size of Manhattan and would beam electricity via microwaves to large terrestrial receiving stations. The Congressional Office of Technology Assessment did an evaluation of the SPS and asked ILSR to compare space based solar with rooftop based solar. We found that although the sun shines 24 hours a day in space, rooftop solar is still more economical and certainly immensely more attractive politically (see *Decentralized Photovoltaics*. ILSR 1980, available at newrules.org.)

In 2008, the Institute for Local Self-Reliance again examined the centralized vs. decentralized issue and based on current technology and economics, we concluded that while the cost of production may be lower in high solar and high wind speed areas, when the costs of transporting that electricity to the ultimate customer are taken into account, the overall cost may be higher. Moreover, to transport that electricity would require government to seize hundreds of thousands of acres of private land.

Most environmental and alternative energy advocates argue that this is not an either/or proposition. Our needs for renewable electricity are so great that we will need big and small, centralized and decentralized. That may prove true. But centralized and decentralized power plants have very different dynamics and their introduction and proliferation involves very different levels of government.

Centralized facilities require federal intervention and federal intervention often preempts local authority and undermines the ability to build decentralized power. And as some have noted, high voltage transmission lines are popular in part because they are technology neutral. They can carry coal-fired electricity or nuclear power or wind power. The government and industry is vigorously trying to develop "clean coal" technologies, and some environmentalists are beginning to embrace a revival of nuclear energy because of its low carbon footprint. Advocates of decentralized energy generation note that we can close the door on a coal or nuclear powered future by not building new high voltage transmission lines, while the rapid expansion of wind and solar power in a distributed manner does not require a massive investment in new lines.

The rules for centralized power will be established in Washington. Decentralized energy generation, on the other hand, is largely the province of state and local governments. The rules for decentralized power will be established in thousands of state legislatures and city councils and county commissions.

Happily, we are witnessing a resurgence of local activism on a scale not seen since *Self-Reliant Cities* was written. Over 800 cities have formally signed a Kyoto-type agreement to reduce their greenhouse gas emissions. Cities now vie with one another to claim the mantle of green leadership.

Every week brings new examples from the revived local energy movement. In the summer of 2008, the cities of St. Paul and Minneapolis unveiled their Solar Cities initiative, part of which harkens back to the 1970s by redesigning building codes and introducing solar access ordinances to accelerate the use of solar energy.

It is gratifying to see some of the images of the future contained in *Self-Reliant Cities* coming to reality. The book muses, "If a single-family detached house's rooftop is oriented correctly, sufficient solar cells can be installed not only to generate all the household's energy needs but to have enough left over for an electric vehicle. We may see the car treated as a household appliance, like the refrigerator or the hot-water heater…. We might see a different relationship in the future between house and car. When the vehicle runs low, it plugs into house current. When the house's batteries are exhausted during an emergency, it has a backup in the electric batteries of the car."

In 2007, I traveled through California to report on the future of the car for the travel magazine, *Travel+Leisure.* I drove or was driven in everything from a glorified electric golf cart to a plug-in hybrid to the zero to 60 in under 4 seconds Tesla. I found that everyone who owned an electrified vehicle had solar cells on their rooftop, and several used the car as a backup when the utility power supply was interrupted.

In 2008, Southern California Edison began building the equivalent of a medium sized power plant (250 MW) by installing solar electric panels on the flat roofs of hundreds of Los Angeles businesses. San Francisco and San Jose are rolling out city-wide charging networks to nurture the introduction of electric vehicles whose battery capacity will itself encourage and enable rooftop solar systems. Some cities are talking about building solar canopies over parking lots, where commuters can park and recharge their batteries, while their cars are shaded from the very hot California summer sun by the solar canopy. Counties in Minnesota have successfully lobbied the state legislature to enact laws that encourage locally owned and distributed wind power plants.

The second part of *Self-Reliant Cities* describes the first urban-based localization movement. In 2008, we are witnessing the revival of the 1970s movement that advocated a dramatic shortening of our long distance distribution lines. This new relocalization initiative is based on a central tenet of *Small is Beautiful.* Schumacher coined the term "Buddhist Economics" to describe an economics in which transportation is viewed as a necessary evil, to be minimized, not maximized while local production from local resources to meet local needs was emphasized.

The relocalization initiative has spread far beyond the energy sector. The local foods movement has become a national phenomenon, now strong enough to influence legislation at the local and state levels. And that movement has broadened the definition of sustainable agriculture. As food writer Michael Pollan, author of *The Omnivore's Dilemma*, proclaims, "local" has become the new "organic".

Self-Reliant Cities reports on communities taking the first steps on the learning curve toward relocalization. Some of the obstacles they faced also face the new relocalization movement. When designing a solar access ordinance, for example, how does one compare the environmental benefits of a neighbor's tree that might shade a solar collector versus the solar collector itself? How can cities overcome the bias toward centralized and absentee owned systems contained in federal and sometimes state incentives? How can we persuade cities that investments in energy efficiency and renewable energy should be part of their capital budget. not their operating budgets, but that they are different from conventional public works investments in that they reduce operating costs and therefore, unlike investments in roads or sewage systems, can repay the debt our of savings? How can we convince cities, and counties, and school boards to use their bonding capacity to maximize energy efficiency and renewable energy, a goal that can only be achieved if they are willing to accept long payback periods, given that they can borrow money over 20 and even 25 years at low interest rates to construct buildings that will be in place for 50 and even 75 years?

The invitation to read *Self-Reliant Cities* is also an invitation to participate with ILSR in answering these questions.

The first wave of energy-related activism at the local level ended in the early 1980s as a result of political and economic changes. Today we see an eerie similarity, at least with regard to the economic changes. While the price of oil dropped by 75 percent between 1981 and 1985, the price of oil has dropped by 50 percent between June and October 2008. The world is slipping into a recession that may be as severe as the one in 1981. State and local budget cutbacks will be required.

Already we are seeing evidence that governments may be less willing to pay a significant price to reduce greenhouse gases. As part of the overall economic downturn, the flow of capital into renewable energy projects has slowed and in some cases stalled. What priority will energy independence have in an era of scarce financial resources?

It is highly doubtful that the new economic conditions and the rapid fall in the price of oil and natural gas will lead to the kind of interregnum that occurred after *Self-Reliant Cities* was first published, if only because the renewable energy industries are now both economically and politically powerful.

As the aftermath of the publication of *Self-Reliant Cities* demonstrated, we cannot know the future. But as computer scientist and visionary Alan Kay has written, "The best way to predict the future is to invent it". In 2008, as in 1980, cities and their citizens are again inventing their energy future.

We believe the cautionary yet hopeful final words of *Self-Reliant Cities* are as relevant in 2008 as they were 26 years ago.

"There are powerful forces working to move us toward local self-reliance. But there is no inevitability that we will achieve that goal. Institutions change slowly. Habits and customs change even more slowly. When people redefine their functions and new institutions arise to take care of new desires and needs, old institutions feel threatened. Structural tensions arise. The tension between the old and the new is the catalyst for change in any society, but the gap between old and new is now growing wider, and therefore the kinds of change and the rapidity of change will become more profound.

Bertrand Russell once remarked, "Change is one thing; progress is another. Change is scientific, progress is ethical. Change is indubitable, whereas progress is a matter of controversy." Will we have change or progress? We can't know yet. But our cities–as the homes for the majority of our population, as the seats of government closest to the people, as the communities most interested in developments that foster local self-reliance–our cities will certainly be in the forefront in determining the answer.

We have attached to this foreword the last chapter of *Self-Reliant Cities*. The complete book can be found at: http://www.ilsr.org/pubs/selfreliantcities.pdf

CHAPTER 9

The Ecological City

We wring material from the earth, we use it, and after its span of life it disperses by rot, fire, or corrosion back into the earth, into the air, or into the sea. It may not again become sufficiently reconcentrated by natural forces to the point of industrial usefulness for geologic ages. Wherever we are able to shorten this cycle, we are able to use materials more intensively with less net drain on what the earth still provides.
Paley Commission Report, 1952

America's cities are built on nineteenth and early twentieth century technologies. The giant industrial cities were products first of the coal-fired steam engine, which centralized industry and created the economic rationale for densely populating the cities. Then, the density of people and industry in those great cities outstripped the capability of the environment to handle their wastes. Huge amounts of water, fuels, and food had to be imported just to keep the city alive. And so the city was transformed from a self-sufficient community into a parasitical creature, dependent on great public-works projects for its survival. Chicago, for example, reversed the flow of the Chicago River so that it would not pollute drinking water from Lake Michigan; Los Angeles brought water from hundreds of miles away to build a city in the desert.

The steam engine gave way to the steam turbine and the central electric power station. Alternating current, developed by Tesla in the 1880s, allowed power plants to locate anywhere and deliver electricity anywhere. And alternating current, along with another invention, the internal combustion engine, exploded the densely populated core of the city, spreading the fragments over the countryside. Anywhere a road could be built, anywhere a power line could go–and that was just about everywhere–a town could be built, or a factory, or a housing subdivision. People no longer needed to live near their workplaces.

And people no longer bought products from nearby small businesses. No longer did the bread come from the local bakery or the beer from local breweries. Business grew larger as production systems grew larger, driven by the power unleashed by the use of concentrated fuels. Dines lengthened. Whereas in the nineteenth century only the richest homeowners could afford to grace their buildings with marble brought from far-off places, in the twentieth the typical home builder imported materials that collectively had traveled tens of thousands of miles.

There was, to be sure, a reason that things came from so far away. Manufacturing facilities were located near the richest ore deposits. Steel plants were located near coal and iron deposits. Paper companies were located near forests. Agricultural enterprises were located where the soils were best and the growing seasons the longest. But as the century wore on, the richest ore deposits were exhausted, and lower grade reserves were mined. Much more rock had to be pulverized to get less useful material, and oil wells that were only a few hundred feet deep at the turn of the century became several miles deep by mid-century. The farms became ever more productive, but the amount of energy required to get the vegetables to market rapidly increased so that by the mid-1970s we were consuming more energy to transport the produce than to grow it.

In the 1970s, the unprecedented rise in energy prices brought home the cost of the parasitical cities and long supply lines. Rising energy prices encourage moving production and consumption closer together, shortening distribution systems. They encourage us to recycle our used products and wastes in order to capture the energy embodied in them during the conversion of the original virgin material into the final product. And rising energy prices encourage us to develop integrated systems, in which production, consumption, and disposal are only points on a continuum.

The rising prices of fossil fuels encourage not only the more efficient use of fuel but the use of renewable energy sources, such as direct sunlight. Unlike coal, uranium, natural gas, and oil, renewable fuels are widely distributed naturally, lending themselves to energy-generation facilities that also are widely distributed. So rather than moving petroleum ten thousand miles to heat our homes, direct sunlight can be converted to heat at our own points on the map–our households.

The pending exhaustion of our richest fossil fuel deposits is only a part of a larger raw materials problem. To prepare for future shortages in key materials, industry is working in two ways: first, developing technologies that recycle materials; second, developing techniques for expanding the ability of such abundant materials as sand and plant matter to substitute for those in short supply. Both kinds of development encourage more localized production systems. As we substitute abundant materials for scarce ones, extractive and conversion industries will tend to become more regionalized. Sand, for example, is an almost ubiquitous material. Plant matter can become a substitute for petroleum as a source of industrial chemicals.

These abundant materials will not be located within city limits, but they will be found close by. The city will still import the raw materials–the transportation lines, however, will be greatly shortened. Recycling encourages a more central role for cities. Since urban areas are our major repositories of post-consumer scrap and human waste, they will logically become the focal points for recycling efforts.

Rising energy and materials prices also encourage local self-reliance. And modern science makes it possible; the harnessing of concentrated fuels a century ago sparked a tremendous outpouring of scientific discovery. At first scientific techniques were used to create crude technologies that tried to subdue nature. But later, especially after World War II, the physical sciences gave way to the biological sciences as the leading edge of modern knowledge, and this led us in turn to a new view of the world, from the linear, mechanistic physics of Newton to more systemic biological concepts. We used to see a car only in a mechanical way, as a vehicle that moved people around. But now we realize its effects on the larger system. Its pollutants decrease the amount of sunlight striking the surface of the city. And vehicles shaped and sized the way ours are demand a large amount of road surface; Los Angeles devotes 65 percent of its land area to the car's needs, and urban planners ordinarily set aside a quarter to a third of the land area of a city for the automobile. By paving over large areas of soil inside the city, the ground's ability to absorb and retain rainfall is reduced and this increases the difficulty of treating the torrential flood of waters that therefore mingles with human wastes in our waste-water treatment systems.

In retrospect, the 1970s may be remembered as the era during which the exponential depletion of our natural resource base ran head on into the exponential expansion of our knowledge base. We had used older scientific principles to fashion technologies that had an immense impact on the environment, and at the same time newer scientific developments allowed us to monitor those impacts and design new technologies to minimize or avoid raw material depletion. The ten-story coal shovel that moves mountains aside to dig for coal represents the old. The tiny solar cell sitting on the rooftop generating electricity represents the new.

Modern science plays a critical role in the expansion of the three key industries of the energy-efficient and resource-efficient era: energy conservation and renewable energy technologies, recycling, and communications. Advances in these industries come not from mining more ore or building larger factories but from applying accumulated wisdom to do more with less. Businesses within these industries are competitive only in as much as they can increase productivity by consuming fewer raw materials. Energy conservation depends on getting a greater amount of useful work out of a given unit of energy. Recycling depends on minimizing waste. Communication depends on making increasingly efficient use of the nondepletable electromagnetic spectrum.

The combination of modern science with energy-efficient planning may change the way we relate to our surroundings–the way we think of ourselves, our homes, and our communities. Within a few years, for example, our rooftops will not only protect us from the elements, but with the installation of photovoltaic shingles will convert one of the elements, direct sunlight, into electricity to power our homes and our cars. The earth will be seen not only as a foundation for our buildings but as a source of heat to warm our homes and offices. The aquifers that run beneath our communities may become not only sources of drinking water but storage tanks for heat.

As the new technologies enter our homes and offices, as the new biological ways of thinking proliferate, communities may begin to think of themselves as part of a complex natural system, not as something separate. As Sir Frederick Soddy, an English scientist, once commented, "Men in the economic sense exist solely by virtue of being able to draw on the energy of nature." We used to draw on the energy of nature by digging up concentrated sources. Fossil fuels are, after all, nothing more than the fossilized remains of plants that used sunlight to generate energy through the process of photosynthesis. Modern science teaches us how to use the energy generated by nature daily to meet our needs.

We are moving, then, into a biological, scientific, communications age. The implications are profound. The new awareness of the interrelationship of the different parts of the urban environment could lead us to abolish the compartmentalization that plagues our cities. Sanitation systems, water systems, energy systems, communications systems could all be seen as a part of a comprehensive whole, a natural resource utility. The advent of home computers gives citizens the capability not only to retrieve large amounts of information but also to analyze and correlate that information. This ability to understand the human, capital, and natural resources in the community and the future impact of current actions could generate a new role–the citizen-planner.

Transporting Materials and Goods: Closing the Loop

The tomato the Bostonian eats, even in season, usually comes from Florida, Mexico, or California. The steel in the office buildings in Phoenix comes from Ohio or Pennsylvania. The oil that heats the homes of New Yorkers comes from Saudi Arabia, while that used to heat the homes of San Franciscans comes from Alaska.

One effect of rising energy prices, however, is to encourage us to reduce the movement of materials–to move toward local self-reliance. About one-third of our raw materials consist of fossil fuels; as our communities use energy more efficiently and shift to such renewable sunlight or plant matter, the transportation required for fuels will drop significantly.

But rising energy prices lead to more than reduced movement of fossil fuels. They also induce materials recycling. According to Harvard geologist Harvey Brooks, the extraction and processing of raw materials accounts for about two-thirds of all industrial energy use in the United States, or about 25 percent of all energy consumption. A finished product contains within it, in effect, all the energy used to mine the virgin ore, to transport it to the refinery, to process the refined material into a finished product. When we recycle a product, we save all that energy. The energy required to produce a ton of steel from urban waste is only 14 percent of that needed to produce a ton of steel from raw ore; for copper the figure is 9 percent, and for aluminum, about 5 percent.

Recycling saves more than energy–it saves materials, and it reduces air and water pollution. As scrap materials have become more valuable, the infant recycling centers of the early 1970s have grown into major industries. Some industries, like glass and paper, have developed factories that operate on 100 percent scrap material. Scrap industries, like any manufacturing businesses, locate near their source of supplies, and since our urban areas are the major storehouses of post-consumer scrap, they are becoming the centers for future scrap industries.

A city of two hundred thousand annually throws away the amount of copper produced by a small copper mine, the amount of aluminum taken from a modest bauxite deposit, and as much paper as comes from a medium-sized timber stand. Until recently, the millions of tons of municipal waste were thrown away together. But the new value of recycled products is already enticing communities to encourage or even require businesses and residents to keep the major materials separate. Several paper companies have already announced that future plants will be built only in communities that recycle aggressively.

Solid waste is only a part of the municipal waste stream. Our human wastes contain millions of tons of nutrients useful for soil conditioning. One of the reasons that human-waste recycling is becoming increasingly common, despite the difficulty of handling sludge and the opposition of neighbors, is that rising energy costs have made incineration–

one of the most favored methods of disposal–too expensive. About nine million dry tons of sludge are produced nationally each year, more than double the estimates of six years ago, and sludge output is expected to increase another 25 percent before this century's end. As sludge is dried and spread on surrounding farmland, and vegetables are grown on the land, the production and consumption and disposal systems become part of the same closed loop.

The concept of recycling goes beyond the use of scrap to the creation of integrated systems, in which the wastes of one process become the raw materials for another. Indeed, in an energy-efficient society the very word waste will lose its present meaning; very little will be literally thrown away. We have already seen how the increasing price of energy has made economical the use of the heat as well as the electricity generated by the combustion of fuel in power plants, doubling the useful work gained from a unit of energy.

Communities and industries are searching for ways to use the previously discarded heat from power plants and manufacturing processes. The city of Ottawa, Kansas, population eleven thousand, for example, is investigating the feasibility of using waste heat from its two municipally owned power plants to produce alcohol. "Since we'd be operating the project without fuel costs," says Ottawa City Manager Robert Mills, "we could net between 20 and 25 cents a gallon or up to $3 million a year."[1] If Ottawa reaches that objective, it would net revenue almost equal to its present operating budget.

Integrated systems are changing the way we see traditional operations. Fort Collins, Colorado, population ninety thousand, processes the methane gas generated from its sewage plant for use in automobiles. Much of the municipal vehicle fleet now has a dual fuel capacity. At the flip of a switch the driver can change over from gasoline to methane. The other product of the sewage plant is nutrient rich sludge. This fertilizes 600 acres of corn growing on city owned land. Far sighted city manager John Arnold hopes to convert a portion of the corn crop to alcohol to fuel still more municipal cars. Fort Collins used to pay to throw away its raw materials. Now it uses them to generate revenue. The city has transformed a waste disposal facility into a production plant.

Integrated systems and recycling can reduce considerably the amount of raw material and energy we need to sustain our communities. Obviously, though, recycling cannot meet all our material needs. We will need virgin materials to supplement recycled materials. But as material shortages become more pronounced, we will substitute more abundant materials for those in short supply and substitute renewable resources for those that are exhaustible. As a result of advances in science, we can do both, and as we do, the materials system can become more local–the new materials will be more dispersed throughout the country.

One material that is becoming increasingly useful is common sand–silicon dioxide. Silicon constitutes 27 percent of the earth's crust. It is the only commodity produced in every one of our 50 states. It is found in a significant number of our 3,000 counties.

Silicon, besides being the basis of the electronics and glass industries, is already replacing metals. For example, glass fibers are beginning to replace the traditional copper wires in the communications industry. A typical copper telephone cable is three inches thick, weighs less than nine pounds per foot and carries about thirty-two thousand telephone conversations at one time. A comparable glass cable is one half inch thick (most of that is plastic filler), weighs one-tenth of a pound per foot, and carries forty-eight thousand telephone conversations at once. It is also easier to maintain, needs only one-third as many amplifiers as copper (with which amplifiers must be installed every 1.5 miles to increase the signal) and costs half as much as copper wire.

The National Academy of Science, in a report on the potential for nonmetallic substances to replace scarce metals, foresaw a major role for the forms of glass. They are, the study noted, "remarkably versatile materials used hardly at all in proportion to their potential abundance. The properties of glass include excellent corrosion resistance and very high intrinsic strength." The crystal structure of silica and silicate minerals, "each with attendant special physical properties, already provides a basis for future substitutions for the scarce metals."[2] Low-density special glass can now be made stronger than most metals. Glass-ceramic materials have been made having flexural strength up to 200,000 pounds per square inch, comparable to many metal alloys.

A silicon-based economy will be one part of our raw material base. The other part will continue to be based on carbon. But instead of taking carbon from the fossilized remains of prehistoric photosynthesis, we will use plant matter more directly. Before cheap petroleum supplies were discovered, after World War II, the use of agricultural crops as industrial materials was explored a great deal. Henry Ford was one of the major supporters of the exploration. In 1935 Ford and three hundred other leaders of agriculture, industry, and science formed the Farm Chemurgic Council. Its major objective was the gradual absorption of the domestic farm surplus by domestic industry. It announced, "The program of the Farm Chemurgic Council is founded on the timely unfolding of Nature's laws through which modern science has placed new tools in the hands of men, enabling a variety of surplus products of the soil to be transformed through organic chemistry into raw materials usable in industry. Basic research has progressed sufficiently for the commercial application to begin without delay. Here lies a new frontier to conquer that challenges the genius of science, the courage of private industry and the productive capacity of agriculture."[3]

Henry Ford succeeded in making plastics from soybeans during World War II. But cheap petroleum supplies after the war eclipsed the infant industry based on converting plant matter into industrial chemicals. More recently, however, the rising price of petroleum, and therefore of petroleum-based products, has revived interest in agricultural factories. Advances in enzymatic technologies combined with the aggressive interest in alcohol conversion has added to the revival-we are rapidly approaching a time when we will be able to supply ourselves with alternatives to oil-derived chemicals for making fertilizers, plastics, clothes, dyes, paints, and tens of thousands of other products.

Recycling will transform our urban areas from consumers into providers of raw materials. In addition, the substitution of widely accessible resource materials–those that are locally available–for those imported from far away will in effect move the farms, wells, and mines closer to urban populations. That is, the substitution will allow local producers to do more of their business locally. This market expansion in turn allows new local manufacturing, processing, and assembly operations to develop. But such development can take place only if the new, small factory can make a product or provide a service that costs no more than the imported good. Probably, it can. To begin with, industries that use scrap materials cost less to start than those that use virgin materials. A typical traditional steel mill can produce five million tons of steel annually. But the fastest-growing sector in the domestic steel industry is of plants that use 100 percent scrap steel, and electric furnaces that consume only 20 percent of the energy used in the conventional plants.

These reprocessing plants produce as little as three-hundred thousand tons annually. Surprisingly, even in traditional manufacturing industries far fewer economies are achieved by building large factories than one would expect. Indeed, the size of the average factory in the United States has not increased at all in most industries since World War I. Tiny factories can produce products at prices competitive with those of much larger factories; and, returning to the advantages of local supply, the less one has to produce to be economically healthy, the less one has to sell outside the local area.

The energy situation, rather than marking the end of industrial civilization, has opened up a new development path. The movement of raw materials will decline markedly as communities begin to use modern science to convert such common materials as sand, plant matter, and sunlight into useful products. Two of the fastest growing industries in the world right now are founded on the principle of doing more with less: energy conservation is based on increasing the amount of useful work we gain from consuming a unit of energy; recycling's goal is to minimize waste.

But the most rapidly growing industry of all is also an industry upon which all other parts of the economy are based–knowledge and communications. As we reduce the movement of materials, we increase the movement of information by electronic means.

Transporting Electrons: Harnessing the Electromagnetic Spectrum

The phenomenal growth of the electronics and communications industries is well known. A computer that filled a room and cost half a million dollars in 1959 can now fit on one's fingernail and costs $5. In 1960 Standard and Poor's register of industrial companies had no "Semiconductor and Related Devices" category; in 1970, 85 companies were listed in that category, and in 1978, 147. In 1975 the world's first computer store opened in Los Angeles. By 1978, 700 such stores operated in the United States alone. Already, computers exist that speak, that listen, that read.

The growth of the electronics, computer, and communications industries is based on the ability to get more productivity out of fewer raw materials. The objective is to store more information on a given area. Every two years, the semiconductor industry quadruples the amount of memory that can be stored for the same price. Indeed, Carl Sagan in his book The Dragons of Eden estimates that the logic of a human brain is equivalent to ten thousand billion elementary electronic logic circuits; if his estimate is accurate, some computer experts believe, within 20 years we will be able to buy enough electronic logic to match the human brain for less than $1 million–perhaps for only a few thousand dollars.

The hardware of communications systems is increasingly energy efficient as more capability is packed into a silicon chip. But even more compelling a case can be made for the energy efficiency of the electronics industry when we realize that the fastest-growing component of the communications industry is not in hardware at all but in software, or programming. The programmer's goal is to tell the computer to analyze and retrieve information in the fewest steps possible, that is, with the smallest number of electronic actions. Since the programmer's work is sitting and thinking, the programming industry is literally based on food calories. Thus the fastest-growing part of our entire economy is based not on the consumption of raw materials or on energy at all, except for food energy. Could one make the case that advances in science have actually allowed us to revert to an agricultural society?

We can now ship vastly greater quantities of electrons from one part of the globe to another using much less energy. The road upon which our electronic freight travels is the electromagnetic spectrum. The way we have broadened the use of this spectrum is comparable to going from country dirt roads to the major interstate highways. But while automobiles have become more and more resource-consuming over the years, taking up more and more of the road, the advances in electronic transmission have allowed us to use less and less of a lane to accomplish the same purpose, and allowed us to continue to open more lanes of this natural highway. In the early 1980s we are using light itself to carry information. These light waves can carry ten thousand times the information carried by telephone technology in 1919, and at far less energy consumption. We have learned to harness electromagnetic waves of higher and higher frequencies (shorter and shorter wavelengths). The higher the frequency, the more information each wave can carry. We have moved from being able to transmit a pale imitation of the human voice via telephone to stereophonic music to the transmission of black and white and then color pictures to the transmission of billions of bits of electronic information that can be translated into sounds, pictures, or words.

The electromagnetic spectrum is not, however, infinite. As we widen our use of its frequencies we begin to bump into other users. At the World Administrative Radio Conference in 1979, the developing countries expressed their concern about the use of microwaves to beam down energy from orbiting solar power satellites. They feared that the wide beams would interfere with their ability to use communications frequencies. We need not look to the skies to see evidence of overlapping frequencies. Heart pacemakers can now operate on the body's own electricity. But those wearing pacemakers must be alert to the presence of microwaves leaking from ovens or transmitting stations.

The spectrum is not infinite, but it is nondepletable. Harvey J. Levin of Resources for the Future wrote in 1971, "Insofar as it is free from depletion upon use, the spectrum has characteristics of a sustained yield (flow) resource of a unique sort, perhaps most similar to solar or water power."[4]

That we could exhaust the potential of the electromagnetic spectrum appears unlikely–it is a constantly renewable highway for transporting information. This aspect of the nature of the resource is crucial, because an energy-efficient society is a knowledge-intensive society. And knowledge increases as communications increase. Scientists learn from other scientists. Policy makers learn from other policy makers. Cultures learn from other cultures. The propagation of knowledge cross-fertilizes the world, fostering a greatly compressed learning curve.

The discovery that the electromagnetic spectrum is a major source of wealth comes at a propitious time for municipalities; they have the authority to issue franchises for cable television. A century ago, cities learned of the value of the electricity franchise and slowly gained an ability to design franchises that enhanced the public welfare. The communication franchise is more complex, but the municipality's ability to create an instrument that can improve the quality of its citizens' lives has never been greater.

Changing Roles in the Energy-Efficient City

The 1980s will prove exceptionally interesting as changes in technology and natural resource-use wash over the society. We will change the way we look at our households, our communities, and our cities. For example, with the advent of residential rooftop solar cells that are grid-connected, we will be able to sell electricity to the local utility. The house will become a revenue producer. Traditional jurisdictions will overlap.

Already, for example, the electric utility industry, in the wake of the decline in electrical demand and of the legalization of independent power production, is undergoing an active internal discussion about its future. Alex Radin, executive director of the American Public Power Association, advises the more than two thousand publicly-owned utilities that they must broaden their functions. They should become full-service energy planners, "a concept derived from the premise that the consumer is interested in certain services provided by energy–that is, heating, cooling, lighting, operation of various appliances, etc.–rather than obtaining electricity per se. Consequently, the objective of the utility should be to provide these services in the most economical or most `cost effective' means possible, whether or not they involve the use of electricity."[5] The utility will assist homeowners and businesspersons to achieve satisfactory individual comfort levels inside their buildings and to have light sufficient to read and work. The utility will satisfy the need rather than supply a given commodity.

But, as we have learned, the concept of energy efficiency now embraces much more than direct fuel conversion. It is more than anything else a design principle. It is more economical to redesign the refrigerator to preserve food while consuming less energy than it is to build new power plants to operate traditionally inefficient refrigerators. It takes less energy to recycle an aluminum can than to manufacture a new one from virgin ore. Will the electric-utility-turned-energy-service-corporation provide architectural assistance to housing developers? Will it become directly involved in land-use planning at the local or regional level? Will it push for energy-efficiency standards for appliances? Will it become involved in planning efficient transportation systems? If it takes on these new functions, it trespasses on the authority of other institutions, such as the city planning department, or the private manufacturer, or the independent design and planning firm.

One of history's ironies is that, just as we are examining the role of monopolistic energy utilities, the original franchises extended to these utilities by local governments are expiring. Many franchise agreements were granted during the 1920s, when state public-service commissions were just getting established and when the utilities spilled over city and state lines and formed giant holding companies. These franchises began expiring in the 1960s, and in the 1980s a great number will come up for renewal. During the process of negotiating franchise renewal, communities can help to shape the future energy utility.

Even if the energy utility restricts its future functions to direct energy generation, distribution, or storage, it will still overlap the jurisdiction of other utilities. Who has authority over the underground aquifers? Already a number of energy researchers are testing the potential for these aquifers to store thermal energy. Most water departments get drinking water from surface water. But as the need for water increases, they are tapping into underground supplies. Should the city water department coordinate activities related to energy and other functions that could use the underground water systems? In many states, riparian rights laws were developed to guarantee downstream water users sufficient water if someone upstream tapped the river. Who will monitor riparian rights to underground aquifers?

Our concept of the rights and responsibilities of private property will probably change in the coming years. Already, as cities begin to understand the value of living systems, they are enacting ordinances that encourage benign environmental activities. In 1972 the city of Palo Alto, California, rezoned almost 5,000 acres within the city as open space to be used primarily for agricultural purposes. After an exhaustive study of the changing legal principles underlying the concept of private property, two attorneys concluded, "Basically we are drawing away from the nineteenth century idea that land's only function is to enable its owner to make money." Increasingly, the attorneys argue, the courts are considering not only the question "Will this use reduce the value of surrounding land?" but also "Will this make the best use of our land resources?"[6]

How will we decide the value of land? Some scientists are starting to quantify the economic worth of living things. Howard Odum, a pioneering ecologist at the University of Florida, argues that trees in their natural state are worth more than $10,000 per acre, or more than $1 million over a hundred-year period–not counting inflation. "There are ecosystems," Odum writes, "capable of using and recycling wastes as a partner of the city without being a drain on the scarce fossil fuels. Soils take up carbon monoxide, forests absorb nutrients, swamps accept and regulate floodwaters."[7] Many others believe the value of living things cannot be estimated purely by their monetary worth. Chief Judge Brown of the Fifth Circuit Court of Appeals, in a comment on a case involving the authority of cities to ban nonreturnable bottles, indicated that city officials could take into account "the immeasurable loss from a silent spring like disturbance of nature's economy."[8]

The environmental movement has learned about the complexity of regulating dynamic technologies with local or national watchdog agencies. To protect living systems, society has developed voluminous regulations on every single piece of equipment used in many industries. More recently, communities have moved toward a simpler regulatory tool; they have established pollution ceilings under which a marketplace is allowed to develop. The first test of this concept has been the use of emission offsets in those parts of the nation where the air contains more than the maximum amount of pollutants. In such regions, no new development can take place without an equal or greater amount of pollutant being withdrawn from the air. One result is that industries that want to move into an area assist existing industries to reduce their pollutant emissions, so that with the new development the overall level will not increase.

Densely populated communities have begun to be concerned not only about the quality of the water they drink and the air they breathe, but about their continued access to vital resources. The electric power blackouts in the 1960s and 1970s demonstrated communities' total reliance on a product with distribution systems that are incredibly complex. In the winter of 1980-81, many cities and towns in Massachusetts were forced to close schools when a combination of circumstances delayed the shipment of natural gas to that part of the country. In northern New Jersey, apparently several teenagers opened drain valves in reservoirs; so much water was lost that the mayor of Newark declared a state of emergency.

Many observers believe that water, rather than energy availability, will become the major issue in the coming decade. In Florida, sink holes have appeared and swallowed parts of urban areas, the result of a dramatically dropping water table. For much of Florida's recent history, water was something to be eliminated. Swamps were drained and rivers rechanneled to make more area available for farming or building. But, according to the *Christian Science Monitor*, "By draining away its water, the state has destroyed its wetlands that provide the delicate balance that allows rainfall to seep into the underground water supply." Now, instead of draining wetlands, "the state government is fighting to protect and buy the remaining swamps."[9]

In fact, many people are already predicting that the battles over water in the 1980s will be more tumultuous than the battles over energy. The problems of scarce water in Arizona and New Mexico and southern California are well known, but the water issue affects the entire country. Because the water tables are dropping, salt water is seeping into the water supplies of towns in Cape Cod and Florida. Santa Cruz, California, in the northern half of the state, has already declared a housing-construction moratorium until the city can accurately inventory its ground-water resources.

Long distribution lines link the fates of disparate groups. Towns in New Mexico that want to increase their populations must work out new water-use plans that also benefit the farmers who need to tap the underground water and the industry that shares the same resource base.

In another unlikely combination of interests, the introduction of modern microprocessors spurs interaction by those who are linked electronically. For example, in 1979 two utilities in southern California, one public and the other private, linked several large commercial buildings electronically so that their electric demand could be monitored by a central computer. When the computer indicates that the overall demand is rising above an agreed-upon maximum, the building managers are notified and turn off certain systems temporarily to reduce the peak demand. The utility benefits by reducing its need for oil-guzzling backup generators. The building owners, in return for this cooperative effort, share a portion of the system's dollar savings.

Shaping the Future Community

Three major forces work together to encourage local self-reliance. First, the increased cost and decreased availability of raw materials, including but not limited to fossil fuels, pushes us to substitute more abundant and renewable materials. This in turn encourages us to recycle our scrap products, to process materials at the local level, and to generate energy nearer the final customer. Second, the extraordinarily rapid development of new technologies, spurred in part by the exponential increase in scientific understanding and in part by rising resource prices, pulls us toward local self-reliance by allowing us increasingly to generate our wealth within our homes. Third, the electronics revolution, a part of the general technological advancement sweeping the nation, allows us to monitor our environment and understand our relationship to it. The electronics revolution also permits us to step outside our homes and communities and look back, to gain a different and perhaps more comprehensive perspective.

The increasing price of fossil fuels leads us to substitute more plentiful fuels, such as wood, water, plant matter, and direct sunlight. These fuels typically are more efficiently converted into useful energy at the local level. Rising energy prices also increase transportation costs, thereby encouraging us to recycle our products and limit the importation of materials from far away. The larger raw-materials problem reinforces recycling and leads to the substitution of sand and plant matter for iron ore and petroleum.

The cost of raw materials provides us the need to move toward local self-reliance; modern technology provides us the possibility. Technological advances allow us to convert sunlight directly into electricity, to create glass as strong as steel from ordinary sand, to convert plants into pharmaceuticals. The fastest-growing industries in the country are now those that are on the cutting edge of technological advance and those that use fewer and fewer raw materials and energy to produce the same amount of finished product.

The electronics revolution allows us to communicate with our environment, both man-made and natural, in unprecedented depth. We can monitor our environment and develop sophisticated feedback systems to make our communities more energy-efficient. We can more efficiently match the supply to the demand, using only as much of a resource as is necessary to satisfy a specific need. When daylight intensity reaches a certain level, the interior lights begin to dim. Community heat storage systems provide the right amount of heat for widely varying customers. Hydroponic plants are fed through automated drip irrigation systems that sense when the feeding is completed.

Electronics also gives us the ability to step outside of ourselves and look back. X rays and sound waves allow us to peek inside the human body and discover the relationships of its many parts. Infrared waves permit us to perceive our homes in a new way, identifying the heat losses. Video graphics can tell us quickly where our pipelines, sewer lines, and wires are located, how many flat roofs are available, and about the community's demographics. The new information expands our perspective. Just as the first space satellite pictures that showed the entire planet earth generated the "Spaceship Earth" metaphor, so our expanded images of our communities using the new techniques will change the way we relate to our surroundings.

There are powerful forces working to move us toward local self-reliance. But there is no inevitability that we will achieve that goal. Institutions change slowly. Habits and customs change even more slowly. When people redefine their functions and new institutions arise to take care of new desires and needs, old institutions feel threatened. Structural tensions arise. The tension between the old and the new is the catalyst for change in any society, but the gap between old and new is now growing wider, and therefore the kinds of change and the rapidity of change will become more profound.

Bertrand Russell once remarked, "Change is one thing; progress is another. Change is scientific, progress is ethical. Change is indubitable, whereas progress is a matter of controversy." Will we have change or progress? We don't yet know. But our cities–as the homes for the majority of our population, as the seats of government closest to the people, as the communities most interested in developments that foster local self-reliance–our cities will certainly be in the forefront in determining the answer.