A Simple Primer on Climate Change Policies and Solutions

By Starhawk
www.starhawk.org
http://www.earthactivisttraining.org/climate_resources.html

This primer is designed to be a quick, short checklist of policies, programs, projects and actions that can be effective in slowing or (let's be optimistic) reversing climate change. My goal is to help us look at how these solutions can fit together and reinforce each other. No one technology or program will help us out of this mess—we need mosaics of solutions that are rooted in place and reflect the diversity of local conditions and cultures.

In this election year, candidates have put forth their own solutions, which mostly fall far short of what is needed. But the good news is this: a transition to a zero carbon, nuclear-free future is absolutely doable, reasonably economical, and may involve less sacrifice than we think. The barriers are political, not technical. And it can be done with solutions that actually improve our overall environmental health, our long-term economic and social well-being, and our true quality of life.

I've tried to keep this clear and brief—something to skim to get the big picture. It's not detailed nor comprehensive, that would require volumes (and funding!) I've simply tried to summarize the major possibilities and to note potential dangers or drawbacks. Each separate item could be the subject of a long discussion and more research. I've provided general references, and some specific references and resources for areas that might be controversial or counterintuitive, all listed at the end.

My overall approach comes from **Permaculture,** a system of ecological design that teaches us how to create systems that can meet human needs while regenerating the environment around us. Permaculture integrates multiple aspects of green technologies and applies systems thinking to earth care and people care. A permaculture design course covers many of the solutions listed below. Earth Activist Trainings, my own organization, teaches permaculture design applied to social systems, organizing and activism as well as land use systems.

I've grouped this list according to the four elements, plus the fifth, spirit and community. At the end are some key sources for technical data and the crunched numbers that back up this short summary.

Data keeps changing and new possibilities open up every day, so think of this as a work in progress, not a final summation.

True Carbon Targets and Goals:

The Intergovernmental Panel on Climate Change has set a goal of keeping the rise in global temperature to 2 to 2.4 degrees Celsius. Globally, an 85% reduction (relative to 2000) of carbon emissions by 2050 would provide an 85% chance of reaching that goal.

For developed countries which are the largest emitters, that means a near total reduction. These figures are also all best guesses—historically we've seen climate change progress faster than estimated, not slower.

The changes necessary to achieve a near-total reduction of CO2 are basically the same changes we need to achieve a zero-carbon future. In practice, our goal should be a zero carbon, nuclear free society, which will also provide us with energy independence and true energy security.

The Kyoto Protocol—went into effect in February, 2005. It's the first and only binding international agreement on climate change. While its goals are modest, it is a beginning step. It calls on governments to reduce emissions below the 1990 levels, with differing levels set for different countries. 182 parties (countries plus the European Union) have ratified the agreement. Clinton signed the agreement for the U.S, but the U.S. has not ratified it, and our failure to do so and opposition has set back the process and encouraged other developed countries, for example, Canada, to renege on their goals.

Carbon Emissions Policies:
Carbon Caps, Carbon Bans, Carbon Taxes, Carbon Rationing, Carbon Trading, etc.--

Carbon Caps put an absolute limit on how much carbon dioxide can be emitted. Caps can be placed on individual enterprises, on industries or regions, or overall by country or international agreement. Makhijani recommends an overall carbon cap on a national basis for large users of fossil fuels, such as utility companies or big manufacturers. This cap would decline each year to zero in 2060 at the latest. Offsets would not be allowed, and free allowances would not be given to existing users (this has been done in Europe and had the effect of rewarding large users.) Allowances or permits would be auctioned each year—rewarding early adopters of alternatives who would need to purchase fewer allowances. This approach places a great deal of responsibility on the largest users, who are also the largest emitters. Penalties for producing emissions beyond the permitted amount or without permits must be higher than the cost of reducing or eliminating emissions.

Carbon caps are harder to enforce on small users—to do so would require an enormous and intrusive bureaucracy that would encounter widespread, grassroots resistance. "Upstream" carbon caps on fossil fuel producers would increase the costs of using fossil fuels for small-scale users—but at a social cost of hardship for the poor and middle class.

Carbon Trading or Cap and Trade—sets an overall cap for emissions and then allows industries, companies or governments who are high emitters to buy unused allowances from low emitters. For this to work to actually reduce emissions overall, the cap must be lowered each year.

Carbon Offsets—allow carbon emitters to pay money to reduce or sequester carbon emissions elsewhere to counterbalance the carbon they are putting into the atmosphere. Typical offsets might be building wind farms to replace coal-fired electricity, planting trees, or paying farmers to adopt soil saving practices that sequester carbon.

Offsets are problematic. When used on a large scale by industries or governments, they can be a license to continue to pollute. It's difficult to tell what activities truly sequester carbon. Offset credits have been offered for cutting down tropical rainforests for palm oil plantations for biodiesel—which puts far more carbon into the atmosphere than it takes out.

On an individual or company-wide, voluntary scale, offsets can be a way to channel funds to worthwhile activities that otherwise might be starved for resources. David Suzuki's website has excellent resources.

Carbon Ban—a ban on the production and use of fossil fuels could be instituted for some time ahead in the future, similar to what was done for CFCs. Bans could also be instituted on certain industries or technologies, for example, a ban on new coal-fired power plants.

Carbon Taxes—would tax producers and/or consumers of fossil fuels. Taxes could be used to make more clear the true cost of consumption. But an across-the-board rise in fuel prices, before alternatives are in place, punishes the poor and the middle classes and raises food prices for the hungry.

Carbon Rationing—George Monbiot proposes a global system of carbon rationing, where each individual would be allocated a certain number of carbon credits, with an overall global cap.

People of means could buy credits from the poor of the undeveloped world, transferring some funds from the rich to the poor and providing resources for development.

This system may be the most just policy proposal, but it's hard to imagine, at least in the United States, that it would become politically feasible before the ice caps melt. It would also require global administrative systems that don't yet exist and which might become intrusive and restrictive if they did. Moreover, it continues to place the bulk of the responsibility on individuals rather than large users and systems.

Government Purchasing—local, state and national governments can provide markets for green technology and alternative energy by their purchasing decisions for their own fleets and enterprises. They can reward early adopters of green alternatives and companies who make a commitment to reducing their carbon footprint, and help provide economies of scale that can bring down costs.

Incentives—industries, small businesses and individuals can be helped to adopt green technology through tax incentives, cost sharing programs, rebates, and other perks; for example, allowing low-emission vehicles to use carpool lanes.

Some helpful concepts:

Embodied energy or emergy:--The amount of energy that has been used to produce, transport, package and market something, plus the energy that will be needed to dispose of it when its useful life is done.

EROEI—Energy return on energy invested--A similar concept—the amount of energy you get back from a source compared to the amount of energy needed to develop, produce and maintain it.

Intermittency--One of the challenges with renewables is the fluctuation in the supplies of energy they deliver. The sun only shines during the day. Wind blows irregularly. Utilities love coal, oil and nuclear plants because they can be turned up or down at need. To shift to renewables, we must store energy in order to have a buffer supply that can be drawn upon at need and replenished when there is a surplus.

Distribution--Renewable energy is often most available in areas far away from the point of greatest need. Wind blows strong on the prairies: sun shines most reliably in the desert, while large urban centers are far away. Part of the challenge and investment needed is in adapting the grid to handle increased supply in remote areas and to minimize the losses in long-distance transmission.

Sources and Stores--A source is something that actually produces energy, like the sun. A store is something that stores energy so that it can be used when needed, like a battery.

Growth economy--A concept that needs to change. An economy cannot expand endlessly in a world of finite resources. Where can we generate abundance while we respect nature's limits? We can grow connections between things. We can get multiple uses out of the same stuff, by reusing and recycling. We can use one thing's wastes as another thing's resources. We can use renewable sources of energy, increase efficiency and reduce waste. And creativity is an unlimited resource.

Carrots and Sticks--Policies should support, encourage and help to pay for the things we want, like use of renewable energy or a shift to organic agriculture. We should tax, penalize, limit, regulate or ban the things we don't want, like use of fossil fuels.

Scale--Can this thing be used on both large and small scales? What scale does it work best on? Does it require centralization? We need solutions at every scale: home-scale, community and small-town scale, national and global scales.

Climate Change Solutions:

Fire--Energy:

Conservation-- will always have the largest EROEI. It's the biggest bang for the buck, because it requires no embodied energy to *not* do something.

Reduce, re-use, recycle—the best place to stop a pollutant is at the source, by not producing it. Re-using something takes less energy and resources than remaking it into something else. Recycling takes less energy and resources than making something from raw materials.

Industrial ecologies—using the wastes from one process as the raw materials for another. Locating production facilities close to one another to take advantage of these resources.

Efficiency—getting more results from less energy and materials, as in replacing old lightbulbs with compact fluorescents or LEDs. Major gains in efficiency can often be made by looking at how systems are designed.

Gains in efficiency are painless and ultimately save money.

Government policies should require high efficiency standards for appliances, high fuel-efficiency standards in transportation or transition to zero-emissions vehicles, and high energy efficiency in new construction. Subsidies and low-interest loans can help fund the transition and the retrofitting of older structures.

Heating and cooling—are major energy users in buildings. Retrofitting existing buildings for insulation, adding sunrooms, shade structures, planting vines or deciduous trees and other low-tech methods can reduce heating and cooling needs. New construction should be held to high standards of insulation and design. Subsidies and low-cost loans can encourage retrofitting.

White roofs and reflective pavement—installing white roofs, shade trees, and light-colored, reflective pavement instead of dark asphalt on the world's hundred largest cities could offset 44 gigatons of carbon emissions. White roofs are cooler, and reduce need for air conditioning, and the reflective surfaces increase the earth's albedo, directly reflecting heat. An international program should be instituted immediately to subsidize new roof installations. Reflective roofs should be required on new construction and on large buildings (or living roofs, solar panels, solar film, etc.)

Passive solar—new buildings should be designed to take advantage of the sun for both heating and cooling. Old buildings can sometimes be retrofitted.

Solar thermal—solar energy concentrated to produce heat. Solar hot water panels are a solar thermal technology. It's highly efficient, reliable, and relatively low-tech.

CSP—Concentrated Solar Power—is a solar thermal technology. Sunlight is concentrated, often with a parabolic mirror, and used to create heat. On a micro-scale, solar ovens can cook food. Water can be heated to generate steam, and the steam used to generate electricity or run mechanical systems. This technology is available on a small scale, suitable for a homestead or a box store. It is also used on a macro-scale, for huge electricity generating plants located in the desert. Oil or other fluids can substitute for water. A steam engine or Stirling engine, which runs on the heat differential, can drive turbines and generate electricity.

Photovoltaics—using sunlight to generate electricity. Many types of panels and films exist currently and more are being developed all the time. In Britain, emergy payback for PV panels is

currently about 4 years, (Monbiot) and increasing all the time. PV power can be used on the microscale—self charging flashlights and backpack chargers—to the macro—huge desert installations.

Companies and government buildings can cover their rooftops and parking lots with PV installations, reducing their heat gain and shading parked cars while providing electricity. Tax credits for solar installations and subsidies for companies and homeowners can help defray the cost of installation, and increased demand and production is already lowering costs.

Photovoltaics must be paired with some form of energy storage, as electricity is generated only when the sun is shining. Some panels use minerals that may be mined in ways that harm the environment and exploit workers.

Cogeneration and Combined Heat and Power—producing electricity where the waste heat of production is then used for heating buildings. Highly efficient, and should be a component of all new utilities.

Heat pumps—using the heat and/or temperature differential of the ground or water to heat buildings. Very efficient, and is already being adopted in colder climates.

Wood heat—useful in rural areas where supplies are local and woodlands can be managed sustainably. Masonry stoves are an old technology that can reduce the amount of wood needed for heat—the thermal mass of the stove, once heated, continues to radiate heat for many hours.

Hydrogen—has strong potential as an energy store, if it is made with solar, wind or other truly renewable energy sources. Hydrogen is made by splitting water into its elements of oxygen and hydrogen, so the process off-gases oxygen. Hydrogen fuel made from renewable energy may be the long-term solution to air travel: Airbus has predicted it will have a viable model within fifteen years.

The challenge in using hydrogen for fuel is that its bulk is large compared to oil or natural gas (although its weight is low.) Burning hydrogen releases water vapor, which itself has some greenhouse impact. And hydrogen made using fossil fuel energy has a negative EROEI—it takes more energy to make the hydrogen than you get in return, resulting in an increase in carbon emissions.

Transportation--Public transportation is generally more efficient than using private vehicles, and makes for a better quality of life in urban areas. However, in some cases busses are less efficient—when ridership is down and distances are large. It is less efficient to run a big bus for a couple of passengers than to transport those same people in a fuel-efficient car.

Transportation policy should encourage use of public transportation by making it frequent, comfortable, efficient and low cost. Fuel efficiency standards should be applied to busses and trains. Long distance train and bus travel should be subsidized, as well as urban public transport.

The need for transport of goods can be reduced by policies that favor localization. The remaining needs can be provided by reviving rail networks and by shifting to biofuels made from truly sustainable sources.

Electric cars and plug in hybrids already exist and should be subsidized with tax breaks and low interest loans. Development of an infrastructure to charge and service such vehicles should be an immediate priority—for example, charging stations could be installed at highway rest stops or by roadside restaurants. Laws should require automakers to sell zero emission vehicles. Speed limits should be lowered, as they were in the 1970s, and rest stops could also offer tire inflation checks and air pumps.

Bicycle lanes and long distance cycling paths safe from cars should be established. Zero-carbon recreation facilities should be favored to provide opportunities for cycling, hiking, swimming, kayaking, skating, skateboarding, sailing, and other sports. Easy public transportation to trailheads and recreation areas and policies to safeguard public access to nature should be adopted.

Storing energy--is one of the great challenges in developing renewables. Intermittent sources of energy—sun, wind, etc. need to be combined with some system of storage so that energy can be available when needed.

Energy can be stored by compressing air or other gases, using phase-change materials, splitting water to make hydrogen, solar pumping of water to be released later, and that primary form of Gaian energy storage, photosynthesis. The primary way that energy is currently stored in small scale systems is with batteries.

Batteries--have been the weak link in many renewable energy systems. Batteries are expensive, contain heavy metals and other pollutants (although they can be recycled) and relatively inefficient. However, new technologies are rapidly improving batteries. Lithium-ion batteries and vanadium flow batteries are far more efficient than older kinds. **V2G** technology--**Vehicle to Grid**—would use plug-in hybrids and electric cars as a grid backup. Cars would be plugged in when parked, and their batteries charged when the grid had excess power. When the grid needed power, it could draw on the energy stored in the vehicles. Owners would be credited for the energy they donate back to the grid, making their electricity costs for running their vehicles extremely low or possibly even making money.

Research, development and larger scale production are needed to bring down the cost of high quality batteries. Batteries contain toxic substances and heavy metals, and recycling of old batteries should be mandatory.

Water:

Climate Change and Water Resources—Water is a vital need, for our survival, for growing crops and providing food. Climate change is already impacting water resources. Changes in weather patterns create floods in some areas, drought in others. Already we are seeing intensified storms, rising seas, increased devastation from hurricanes and tropical storms that draw increased energy from the ocean's heat. Melting glaciers threaten the water supplies of many major cities and billions of people. Desertification and erosion cause wells to dry up and springs to fail.

Water Rights and Social Justice—to effectively find solutions to the water issues posed by climate change, water must be recognized as a basic right. The privatization of water resources and their exploitation for profit must come to an end. Communities must have the ability to conserve and protect their water resources. Policies should protect the right of all people to clean, safe water.

Water and Electricity--Huge amounts of energy are used to pump and transport water. In California, 30% of our electricity is used for water pumping, mostly for agricultural irrigation. Many municipal water systems are old and will need huge investments to repair and replace.

Conservation--Catching warm-up shower water, not flushing or moving to low-flush or composting toilets, turning off taps, all those tricks that help save water also save energy.

Infiltration--The cheapest place to store water is in the ground. Swales, ponds and catch basins catch and infiltrate water on a broad scale. Keyline plows and irrigation systems can provide much needed water for farms and ranches. Rural areas can invest in education and subsidize installations with cost-share programs as forestry departments currently do for restoration projects. Keyline plows—specially designed subsoil plows—can be purchased by agencies and made available to local landowners on a loan or rental basis.

In cities, sidewalk removal programs can encourage the breakup of vast areas of hard pavement. Porous materials exist that can be required in new paving. Parking areas can be designed with pavers that allow grass to grow and water to infiltrate—having the added benefit of cooling the immediate environment.

Stormwater and Runoff Treatment--The city of Los Angeles spends a billion dollars a year bringing water in, and half a billion taking stormwater out. Stormwater in drains, mixed with motor oil and other pollutants, becomes a huge treatment problem.

Porous paving, replacing sidewalks with plantings that allow rainwater to infiltrate the ground, landscaping that encourages infiltration, rainwater catchment and storage reduce both need and waste. New developments can be required to catch water in swales and ponds.

Rainwater harvesting--Catching and storing rainwater for use in gardens, and for other uses including drinking water, can be done on many scales, from a rainbarrel to large scale, underground cisterns. Older buildings can be retrofitted, new buildings should be required to include catchment systems. Local governments can subsidize rainbarrels and provide programs to install or retrofit gutters. Catching rainwater can also reduce the stormwater load on city systems.

Graywater--Sink, laundry and shower water can be given simple treatment and used for gardens, orchards and ponds. Old homes can be retrofitted, new ones can include graywater systems. Building codes should be revised to legalize graywater use and require it in new construction. Requirements should be simplified—currently many building codes that allow legal graywater installations are far more complicated than is necessary.

Biological Sewage Treatment--Sewage can be treated in reedbeds, 'living machines'—series of tanks containing a sequence of micro-organisms, plants and animals that filter and remove pathogens and excess nutrients—or constructed wetlands, all of which use less emergy and produce better results than conventional, chemical treatment.

Composting toilets are very simple to construct and maintain, and can reduce the need for water.

Water Power--Water can be used to generate electricity, and is used on both a mass scale and home-scale micro-hydro systems. Large scale dams, however, disrupt ecosystems, destroy riparian environments and wetlands, and are extremely high in embodied energy. Small scale micro-hydro systems, where appropriate, are extremely efficient as they run twenty-four hours a day. They require volume and head and are mostly applicable in rural settings. Medium scale hydro, with appropriate care for riparian systems, might supply communities and small towns.

Mechanical Water Power--Old style water wheels used the weight of water to drive gears that ground flour, ran sawmills, and did other kinds of work. The Center for Alternative Technology in Wales runs a cliff railway on hydraulic power. A new generation of water mills might do many sorts of useful work, and could revive some of the old towns that fell into depression when manufacturing moved away.

Care must be taken to protect riparian zones and wetland ecosystems.

Tidal Power--Tides are predictable and reliable, and tidal systems have huge potential to generate renewable energy. Tidal barrages pose dangers to local ecosystems: tidal lagoon systems are favored by environmental groups.

Wave Power—The movement of waves embodies huge amounts of energy that could potentially be harnessed to produce electricity. Challenges include translating the choppy, uneven motion of waves into smooth movement. Funding and research are needed.

Algae and Aquatic Plants—algae, water hyacinths, duckweed and other aquatic plants convert sunlight into biomass much more rapidly than terrestrial plants. They can produce more plant material on far less ground and using far fewer resources than land plants. That biomass can be dried, pelletized and burned to produce heat and electricity, or fermented to produce ethanol. Strains of algae can be pressed for oil to make biodiesel.

Exhaust from generators and other stationary fossil fuel producers can be run through algae farms—series of tubes exposed to light--to capture carbon dioxide and increase growth.

Algae can also be used for human and animal feed—but caution must be taken: algae exposed to potential toxins in fuel exhaust should not be eaten. Algae has potential to augment urban and small scale food production.

Water hyacinths and other aquatic plants also remove excess nutrients and some toxins from water, and could be grown as part of sewage treatment or graywater systems, then harvested for their biomass.

Earth:

Soil and Carbon--Soil is the unseen component of climate change. A huge amount of the excess carbon in the atmosphere comes from industrial agricultural practices that expose and erode soil, oxidizing the organic carbon held in humic acids and soil microorganisms and releasing it as carbon dioxide. The world's soils are carbon-hungry, especially in brittle environments—areas that receive uneven amounts of rainfall and are often at risk of desertification. Building healthy, organic soil is one key strategy for reducing climate change.

Plants extract carbon from the atmosphere and turn it into food, plant material, roots and wood, and feed soil micro-organisms that build soil organic carbon. When plants die, their carbon is released and recycled. Finding ways to lock some of that carbon into stable forms can help to offset emissions. Stable forms of long-term carbon storage are in soil organic carbon and in forests.

Farmers around the world are struggling economically. Paying farmers through subsidies and carbon offsets to shift agriculture and grazing practices can both help mitigate climate change and secure family farms and truly sustainable, secure agriculture.

A standard method of measuring soil organic carbon is needed, and effective and economic ways to measure carbon sequestration in soil.

Globally, soil is estimated to have the potential to sequester carbon equal to 24% of global emissions. (Lal)

Forest Protection--Forests and jungles sequester carbon. The older and more massive the tree, the more carbon it turns into wood with each year's growth. An absolute moratorium on the cutting of old growth forests and the conversion of jungle to cropland or ranchland should be instituted immediately.

Countries should be rewarded under international agreements for reducing their rate of deforestation and for protecting forests, rain forests, and reserves.

Sustainable Forestry and Product Substitution--Forests can be managed in ways that preserve the canopy and biomass, enhance growth and soil building, and still produce products to meet human needs, while sequestering carbon.

Governments and corporations can insist that forest products they purchase be sustainably grown and certified by an independent agency such as the Forest Stewardship Council. They can switch to post-consumer recycled products for paper and other needs. Regulations banning hemp, a good substitute for many forest products, can be eliminated.

Small scale, local mills that can handle smaller diameter materials and value added production can encourage diversified forest stands and provide jobs in rural areas. Building codes can be changed to allow the use of poles and rough graded materials.

Tree Planting--Trees can be planted to uptake carbon, shade and cool the ground, build soil, protect streams, produce fruit, nuts and tree crops, and improve air quality in cities. Fast growing trees, grasses and bamboo show promise as a possible way to uptake carbon from the atmosphere.

Organic Agriculture--Our current agricultural system is enormously inefficient and wasteful. We use fossil fuels to produce fertilizers and pesticides that destroy soil organisms, poison farmworkers, cause disease and lessen the nutritional value of food, while using more calories of energy to produce food than we get back from it.

We must shift to forms of agriculture that build and preserve soil organic carbon, that do not require fossil fuel inputs and do not produce toxins.

A global shift to organic, localized agriculture could save 30% of carbon emissions and a sixth of world energy use. (Ho and Ching).

No-Till Agriculture or Conservation Agriculture--When soil is exposed to air, soil organic carbon is oxidized. Systems of agriculture which avoid plowing and keep soil covered, or at least, minimize cultivation, help preserve the soil ecology and keep the carbon sequestered.

The Land Institute in Salina, Kansas is working on breeding perennial grains that will not require annual cultivation.

Local Agriculture:

The average piece of food is transported 1500 miles before it is eaten. We must redevelop our local food systems, growing food close to where it is needed. Land use and zoning policies must preserve farmlands close to cities, and encourage food growing in cities. Community gardens must be seen as vital resources, protected and expanded. Programs to encourage home gardens, urban farming and 'climate victory gardens' can be developed and expanded. Many school garden programs exist and can be expanded. Food growing should be seen as a vital part of education, as important as the three 'r's.

Farmers' markets already exist and can be encouraged and expanded. Community Supported Agriculture, programs to link farmers and consumers directly and to encourage small scale production can be supported and expanded.

The Soil Food Web:

Living soil is a rich ecosystem of bacteria, fungi, protozoa, nematodes, microarthropods, worms, insects and animals. Plants feed this with the products of photosynthesis, making sugars and starches from the carbon in the air. Reintroducing biology to desiccated soils by using compost, manure, mulch and actively aerated compost teas can help the production of soil organic carbons, stable compounds which can sequester carbon for decades and even centuries.

Mycorestoration and Mycoforestry:

Mushrooms and fungi have great abilities to break down toxins and restore soil fertility, and to help the growth of plants and trees. Mushrooms are the fruiting bodies of underground organisms made up of a web of thin threads, fungal hyphae, which are sheathed in glomalin, an organic substance extremely high in carbon. Introduction of mycelium can help restore damaged environments, sequester carbon, and further the growth of forests and crops.

Agro-Char and Tierra Prieta:

In the Amazon rainforest, huge tracts of extremely fertile land exist that were developed by farmers burying charcoal in the soil. The charcoal provides a long, slow release of carbon and a prime environment for the growth of beneficial micro-organisms.

Pyrolysis—the slow burning of wood in low-oxygen conditions—creates charcoal without releasing carbon back into the atmosphere. The charcoal can then be buried to increase soil fertility, with net carbon sequestration. This could be an effective use of small-scale forest materials produced by thinning programs for fire safety and forest health.

Meat:

The relationship of meat production to climate change is often discussed in overly simple terms. Leaving aside moral and religious issues with eating meat, the ecological impact of meat depends on how and where it is produced, as does the ecological impact of grain or vegetable production. A locally produced, grass-fed steak from a holistically-managed grazing regime would embody much less energy than a dish of conventionally grown soybeans transported from Mexico to New York. A slice of bacon from a factory farm that dumps its waste into a local river and shoots its hogs full of antibiotics not only contributes to global warming but to cancer, heart disease, and habitat destruction.

Ruminants—animals that chew their cud, such as cows and sheep, do produce methane, a greenhouse gas, as part of their digestion. However, the high levels of methane production attributed to cows may be a result of feeding them high-corn diets, which their digestive systems are not designed to handle. Grass-fed cows produce less methane—but more specific research is still needed on this question.

Factory Farming of Meat—is tremendously cruel, wasteful, embodies far more energy than it produces, destroys local environments, turns manure into a huge pollutant, puts antibiotics into the environment and lessens their effectiveness against disease, and contributes to human and animal diseases. Subsidies to corn should be ended, concentrated feeding operations and factory farms phased out.

Small-Scale, Local Integrated Systems:

On-farm, small-scale meat production can be done humanely, and is a vital part of conserving and increasing soil fertility in many environments. In many climate zones and soil types, maintaining soil fertility without animal manure is extremely difficult. Eggs and dairy products are an important source of protein, and organically raised meat does not cause the health problems of factory farmed meat and is a vital part of many peoples' diet. Marginal land that is unsuited to grain or vegetable production can be used for grazing. Health and safety regulations should be revised to encourage and support local and small- scale production, on-farm slaughtering, healthy, safe and humane meat production.

Animals can be integrated to provide other farm services, such as mowing, fuel load reduction, ground preparation, plowing, transport of loads, logging, insect and slug control. Ponds can provide both irrigation water and fish.

Markets can be developed and redeveloped for local products—for example, insulation from sheep's wool.

Holistic Management Grazing Regimes:

In brittle environments—climates which receive uneven amounts of rainfall throughout the year—grasslands co-evolved with large herds of grazers and predators which kept the herds bunched together and moving across the landscape. In such environments, overgrazing leads to desertification and biological degradation. But suppression of grazing also leads to degradation and destruction, because these lands need animal impact to break down old vegetation, provide manure for soil fertility, and create conditions that allow for topsoil to be formed. To heal these lands and restore soil fertility, grazers must be managed to mimic the behavior of natural herds, a regime commonly known as 'holistic management grazing,' developed and popularized by Alan Savory, in his book *Holistic Management*.

Grazing can be combined with keyline plowing and subsoiling to infiltrate and store water and encourage the formation of topsoil.

Correctly managed grasslands can build soil fertility and organic matter very quickly and on a large scale, while producing free-range, organic meat and dairy products. Research can be done into 'best practices' and transition to this sort of management can be subsidized. Training programs can be subsidized to produce skilled workers and range managers.

Heritage Breeds:

Heritage breeds of farm animals are a vital resource in adapting production to local conditions and should be preserved.

Bio-Fuels:

Vegetable oil can be used to run diesel engines. Engines can be converted to run on pure vegetable oil, or with little or no modification, can run on biodiesel.

Ethanol—wood alcohol, can be used to run internal combustion engines.

CAUTION: Bio-fuels that recycle waste vegetable oil or other food wastes can be a useful part of a renewable energy policy. However, when food production is diverted to fuel production, when rain forests are cut down or burned to clear ground for palm oil plantations, far

more carbon is put into the atmosphere than is saved by use of the fuel. Food prices rise, causing hunger and deepening poverty. At best, biofuels can produce only a small percentage of the energy we need.

Methane:

Animal manure, human sewage and rotting garbage produce methane, a greenhouse gas which can be captured and used for cooking and heating. Methane digestors can be built on both large and small scales. On a small scale, the average family does not produce enough methane to provide for their cooking needs, but on a farmyard or municipal scale this works well.

Natural Building:

Earth is an ancient building material, and today there is a revival of many different forms of traditional building using earth and plants: adobe, cob, rammed earth, wattle and daub, light straw clay, straw bale, straw wattle, natural plasters, cordwood, thatch, and many more.

Building codes can be revised to allow and encourage building with low carbon footprints and natural materials.

Green Building:

More conventional building can become more efficient at using and recycling materials. New buildings can be required to be zero-carbon or net energy producers, encompassing state-of-the-art passive solar design, insulation and weather-proofing, energy monitoring, etc.

Air:

Emissions capture and sequestration:

Technology exists to capture carbon emissions at source from many different kinds of production facilities. This should be made mandatory, immediately.

Wind Generators:

Offshore wind generators have one of the best EROEI of all the renewables, followed closely by onshore wind. Problems with bird kill have largely been exaggerated, and most have been eliminated by improved design and siting. Wind can provide electricity on a large scale, and also on a small home-scale in the right site. Small, portable systems are also used on boats.

Mechanical Power from Wind:

Windmills once ground grain, sawed wood, pumped water, dried and ground salt, and powered many mechanical systems—in Holland, some are still working after four centuries. Newly designed windmills might again perform many needed mechanical functions.

Sailing:

A new generation of sailing ships might again carry goods across the oceans. Even if other sources of power are also used, wind power could reduce the amount of fuel needed by ships.

Compressed Air:

Compressed air is potentially a highly useful energy store. Solar or other renewable energy can be used to compress the air—as it is released, it can drive mechanical functions. France currently produces cars that run on compressed air.

Air Travel:

At present, no low carbon form of air travel exists. Aircraft can run on biofuels, and testing and research are needed. Biofuels made from recycled or waste materials, and that do not usurp food production for fuel production, could be a sustainable way to preserve the freedom, cultural exchange and convenience of air travel.

Hydrogen, made from water using renewable energy sources, is another long-term potential fuel for air travel. The Airbus consortium estimates that there are no insurmountable technical barriers and that a hydrogen-fueled aircraft could be developed in ten to fifteen years.

In the meantime, air travel should be limited, policies favoring expansion of cheap airlines and building new airports should be abandoned. Flights could be made more expensive with a heavy carbon tax that could be devoted to renewable projects.

Community:

Re-Localization, building community on every level, is the core of a sane climate change policy.

Local Food Systems:
Producing food closer to where it is consumed could offset the energy costs of transport and much packaging, as well as providing fresher products and greater food security, as well as reducing price fluctuations. Zoning and land use laws should protect farmland, encourage community gardens, urban and suburban food production. CSAs and Farmers' Markets should be encouraged. Fresh, local, organic food should be made available in all parts of the city, particularly the inner cities where it is often easier to buy liquor than broccoli. School gardens and education in food growing, preparation and nutrition should be core programs at all levels—and much reading, math, science and other 'hard' subjects can be taught in the setting of a garden. School lunch programs and cafeterias can buy local and provide fresh, organic choices. Urban farmers can rent back yards to produce crops. Waste city land, vacant lots, street dividers can be used for gardens. Street trees can produce fruit or nuts.

Local Economy:

Factories can be required and encouraged to root in place rather than chase around the globe after low wages and lax environmental standards. Net carbon-zero production should be made the goal. Subsidies and other forms of support, including tax breaks, can be given to local enterprises and small businesses. Environmental, health and safety regulations can be reviewed to favor small scale producers instead of large industries. Agencies, schools and government can take the lead in buying local.

Local Currency:

Local currencies, such as Ithaca Dollars or Local Exchange Trading Systems can provide incentives for people to spend money locally.

Local Transportation:

The need for transportation can be reduced by encouraging mixed use zoning, '20 minute neighborhoods' or '10 minute neighborhoods' where needed amenities can be found within a short walk. Zoning and housing policy should encourage people to live close to where they work.

Public transportation can be improved, subsidized, and made more convenient and comfortable. Downtown driving and parking can be banned or discouraged. Ticket machines at bus stops can let people prepay, saving time in stops and boarding. Comfortable shelters can be provided for waiting, and combined with other amenities that further community: community bulletin boards, giveway boxes, book exchange sites, etc. Fun forms of transportation can encourage use: San

Francisco's cable cars could return to being part of the overall public transportation system, instead of a separate tourist attraction with a special fee. Art busses—fantastically decorated moving sculptures like those seen at Burning Man--could entice people out of their cars. Taxi vouchers for the disabled and the elderly can help reduce their need for private cars, and public transport must be made accessible for the disabled. Car sharing programs and hourly rental programs can also reduce car ownership.

Bicycles:

Bike lanes, safe bicycle parking, free transport of bikes on busses and subways encourage more use of this form of transport. Electric-assisted bikes can help the less fit get up the hills. Schools and work places can provide safe lockup and showers to support bike commuting. Stores and groceries can offer delivery services.

Pedestrian Zones:
Pedestrian streets and market areas, car-free zones and parks can make walking a pleasant experience. Walkability should be a key consideration in zoning and planning.

Local Culture:

Support can be given to preserve local cultures, languages, historic sites and traditions. Local arts, music, dance and theater can be subsidized, and places for gatherings can be established and made available. Local newspapers, low power radio, and other local media can be supported.

Placemaking--Gathering places and plazas can be created out of streetcorners and unused land. Projects like the Village Building Convergence in Portland, Oregon or the Ashevillage Bulding Convergence in Asheville, North Carolina are models of how to engage communities in bridging public and private space, creating art and amenities, and strengthening neighborhood pride and connection.

Transition Initiatives—a movement that started in Ireland and Britain, organizing towns and communities to plan for energy descent and localization in response to climate change and peak oil. Transition initiative groups do public education and engage their community to prepare a power-down plan, as well as taking on relevant projects such as tree planting, community gardens, and developing local currencies.

Economics and Social Justice—new jobs and Green industries can be located in the inner city, and training programs can provide opportunities for the disenfranchised. The Apollo Project in Oakland trains inner city youth to install solar panels. Hunters' Point Family in San Francisco pays at risk youth to work in community gardens and start green businesses. The Barefoot College in Tilonia, India teaches older women to be solar engineers, upgrading their status in their society as well as providing a needed service. These are just a few of the examples of many, many programs that link environmental and social justice.

Local Government:

The U.S. Conference of Mayors Climate Protection Agreement—was launched in Seattle in February of 2005. 720 cities have signed on, agreeing to reduce their city's emissions to meet or beat the Kyoto target for the U.S. of 7% reduction below 1990 levels by 2012. They also agree to lobby their state governments to do the same, and for a national bipartisan agreement on climate change.

Policy Review and Guidelines:

Local governments can review their laws and policies to find which ones conflict with carbon reduction goals, and begin to systematically change them. For example, many towns have regulations against keeping backyard chickens, or catching rainwater.

Standards for natural building techniques and water catchment and re-use can be reviewed to make them safe, but not onerous for those who wish to retrofit or build sustainably.

Positive Policies:

A policy sheet of recommendations can be developed and new policies put in place to encourage, support, and/or subsidize solutions.

Education:

Education in ecology and training in implementing climate change solutions can become a key part of public education at every level. Local governments can also establish and support research and showcase models of solutions.

Spirit and Values:

Ultimately, responding to climate change demands that we shift our values, from things to relationships, from owning and acquiring to sharing and experiencing, from seeing ourselves as separate from nature to understanding that we are nature working, and to deeply valuing and honoring the interconnectedness, diversity and beauty of the natural world and the ecosystems that sustain us.

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