Jobs in a Clean Energy Economy: Science, Engineering, and Policy Perspectives

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Policymakers are investing in the clean energy industry because it creates jobs at home, contributes to our nation's energy independence, and preserves the environment. The renewable energy sector generates more jobs per unit of energy than the fossil fuel sector. For example, the wind industry generates more jobs per megawatt hour than the coal, gas, and nuclear power industries. Currently, energy efficiency is the most promising clean energy policy direction because it saves the most money and also the most carbon emissions. More than many industries, the clean energy sector demands long time frames and sizeable capital investments. Companies are more apt to make the robust, long-term investments that are needed when governments set consistent and predictable energy and environmental policies. From a family perspective, policymakers need to consider our responsibility for any environmental problems that today's actions are causing for our children, grandchildren, and future generations.

One of the greatest challenges of the 21st century is the transition to clean energy. Investments are being made in the clean energy industry for three main reasons:

- **Sustainable economic growth** – The development of locally available sources of clean energy will create more local jobs than the fossil fuel economies of the last century. What's more, investments in energy efficiency will redirect money away from being spent on the cost of producing energy and toward the costs of saving energy. This can create a large number of new jobs.[1]
- **Greater energy independence** – The more energy dollars that are spent locally, the more money that is reinvested back home rather than being sent overseas to Iraq, Nigeria, Mexico, Saudi Arabia, or Venezuela. Renewable energy is a fuel that, by definition, is free. There is no charge for harvesting the wind or the sun, so more dollars remain for investing in hardware and in people to make those technologies. By contributing to our energy security, clean energy is also an investment in our national security.[2, 3]
- **Reduced greenhouse gas emissions** – The Intergovernmental Panel on Climate Change, which was awarded the 2007 Nobel Peace Prize, has set environmental targets. By the year 2050, industrialized nations need to reduce greenhouse gas emissions (GHG) by 80%-95% from 1990 levels or risk dangerous environmental consequences.[4]

The more energy dollars that are spent locally, the more money that is reinvested back home rather than being sent overseas.

Now is an opportune time to invest in a clean energy economy because it can create jobs in the short run and preserve the environment for decades to come.

Greater investment in renewable energy can build a foundation for economic stability, sustainability, and growth.

In this chapter, I begin by defining a clean energy economy and explaining why this topic is of interest to the Family Impact Seminars. Then I turn to what clean energy sources can offset the demand for fossil fuels, and how many jobs can be created. Next, I cite several examples of specific steps that states have taken as well as steps states can take to build a more independent and secure energy future.

What is a Clean Energy Economy?

In a recent report from the National Governors Association,[5] clean energy is a broad term that includes the following:

- Renewable energy sources (i.e., non-fossil fuel energy sources that can never be completely consumed such as solar radiation, geothermal, wind, tidal power, biomass, wave power, hydropower, and ocean thermal gradients)
- Clean, nonrenewable energy technologies (e.g., clean coal plants that capture carbon and store it)
- Efficiency technologies (e.g., compact fluorescent lights; efficient water heaters; improved refrigerators and freezers; advanced building control technologies; advances in heating, ventilation, and cooling; and a new generation of solid state lighting)
- Advanced energy storage technologies (e.g., lithium batteries for hybrid and electric vehicles; load leveling and peak shaving for electric power; and electrochemical devices, such as supercapacitors)

Why are the Family Impact Seminars Interested in a Clean Energy Economy?

One of the main benefits of a clean energy economy is quality of life—families live in a cleaner environment. Families also save money and experience fewer fluctuations in cost. Of course, the jobs created by the clean energy industry can help families support the economic well-being of their members.[6]

From a family perspective, policymakers need to consider our responsibility for any environmental problems that today's actions are causing for our children, grandchildren, and future generations.

Moreover, doing harm to the environment is a problem that people of the past and people of today are causing for those yet to come. Our economic system is based on privileging today instead of tomorrow. Yet, when it comes to the environment, our actions or inactions that affect our lives in small ways today, may result in dramatic changes tomorrow. What responsibility do we have for environmental problems that we are causing for our children, for our grandchildren, and for future generations? What steps can policymakers take to ensure inter-generational equity?

What Clean Energy Sources Can Reduce the Use of Fossil Fuels?

Energy efficiency is the most promising policy direction for cleaning up our energy situation. The next most promising investments include renewable energy sources such as solar power, wind, biofuels, hydro power, and harvesting the waste gasses from landfills as well as new technologies like Smart Grids.

Energy Efficiency

The biggest success story in the energy economy so far is energy efficiency. It saves the most money and also the most carbon emissions. A few states, including Wisconsin, California, Florida, New York, and Rhode Island, are already leaders in this area. These states have put into place aggressive measures to promote science-based technologies (e.g., advanced building standards, compact fluorescent light bulbs, energy-efficient window materials, a new generation of solid-state lights, tankless water heaters, etc.).[7] These energy-saving measures are attractive because they come, not at a cost, but at a financial savings. The most energy efficient states are almost half as energy intensive as the rest of the country—an amazing difference given that their life styles are fairly similar. In fact, individuals, families, and companies who have invested in energy efficiency consistently report that they have seen an immediate reduction in their energy bills.[8]

The biggest success story in the energy economy so far is energy efficiency.

Solar and Wind

In 2007, the technologies with the largest share of investment were wind (43%), solar photovoltaic cells (30%), and solar water heaters (10%). In fact, wind and solar have grown more than 25% per year for over a decade. Wind is, by far, the fastest growing sector of the energy economy and is already cost competitive with natural gas. Companies are also working on low-cost solar panels and batteries to store the power.[9]

Biofuels

The United States is finally growing a biofuel economy, based almost entirely on turning corn and soy into ethanol. Biofuels do diversify the economy and reduce the pressure on petroleum. However, corn and soy require so much fossil fuel for fertilizer, for irrigating the crops, for running the tractors, and for operating the distilleries that there is little benefit over using the gasoline itself.

Some new entrants into the biofuel market are more sustainable, such as fast-growing switch grasses and certain tree species that lend themselves to quick harvesting.[10] Other biofuels can be produced from waste materials, waste from power plants, or CO2 emissions. Feeding these emissions into tanks of algae sucks out the CO2, thereby cleaning the air and, at the same time, producing ethanol.

The Smart Grid

The electricity sector is responsible for 40% of the world's carbon dioxide emissions. Much like energy efficiency, grid technology would be a long-term investment in the efficient use of electrical power to reduce overall energy use. The Smart Grid, a modernized transmission and distribution infrastructure for electricity, can communicate pricing, supply, and demand information in real time that allows for more efficient purchasing, selling, and use of power.

Summary

Taken together, energy efficiency, renewable energy, nuclear power, and clean fossil fuels all are part of a diverse, high-tech energy economy. This mix of strategies can help insulate the economy from the volatility that stems from overreliance on only a few energy technologies.[11]

Can Clean Energy Grow the Economy and Create Jobs?

For each unit of energy delivered, the renewable energy sector generates more jobs than the fossil fuel sector.

Clean energy is already a major economic force. Worldwide investments in renewable energy capacity reached $71 billion in 2007, up from $40 billion in 2005.[12]

Is economic growth linked to a growth in carbon emissions? Or can renewable energy drive both economic development and employment? In a recent analysis, for each unit of energy delivered, the renewable energy sector generates more jobs than the fossil fuel sector. As shown in Table 1, all renewable energy sources produce more jobs than coal and natural gas.

Table 1. Job creation potential* of different energy technologies and energy strategies

Energy Technology or Strategy	Total Job-** Years per GWh***
Solar Photovoltaic (PV)	0.91
Solar Thermal	0.27
Geothermal	0.25
Biomass	0.22
Carbon Capture and Storage	0.18
Wind	0.17
Nuclear	0.15
Coal	0.11
Natural Gas	0.11
Energy Efficiency	0.38

*Average employment effects normalized to the amount of energy produced (for energy technologies) or saved (for energy efficiency).

**Total job years is one full-time equivalent job meaning a person employed for one year. Note that 50 FTEs could mean either 5 full-time jobs over 10 years, 25 jobs over 2 years, or other such combinations.

***GWh is a gigawatt hour, which is equal to one billion watt hours or one thousand megawatt hours.

Several strategies can contribute to lower rates of CO2 emissions and higher rates of job creation. Half a million job years (i.e., full-time job equivalents) can be produced by 2020 in any of the following ways:

(1) Reducing energy growth through greater energy efficiency (.5% per year annual growth compared to 1% growth),

(2) Increasing standards from 7% to 25% for Renewable Portfolio Standards (RPS), that is, standards that mandate a certain percentage of overall electric power must come from renewable sources by a specified date, and

(3) Increasing nuclear power generation capacity from 20% to 30%.

Among the common technologies for providing electric power from renewable energy (see Table 1), the most jobs per unit of electric output are provided by solar photovoltaic technology that converts sunlight directly into electricity. Take the scenario of a 20% RPS target by 2020; doubling the amount of solar PV from 1% to 2% would increase the number of jobs from 399,000 to 732,000 job years. If the national RPS were set at 25% by 2025 and the annual electricity growth rate was .5% instead of 1%, over 2 million jobs would be created; in addition, if low carbon sources were increased by about 50%, over 3 million jobs would be created.[13]

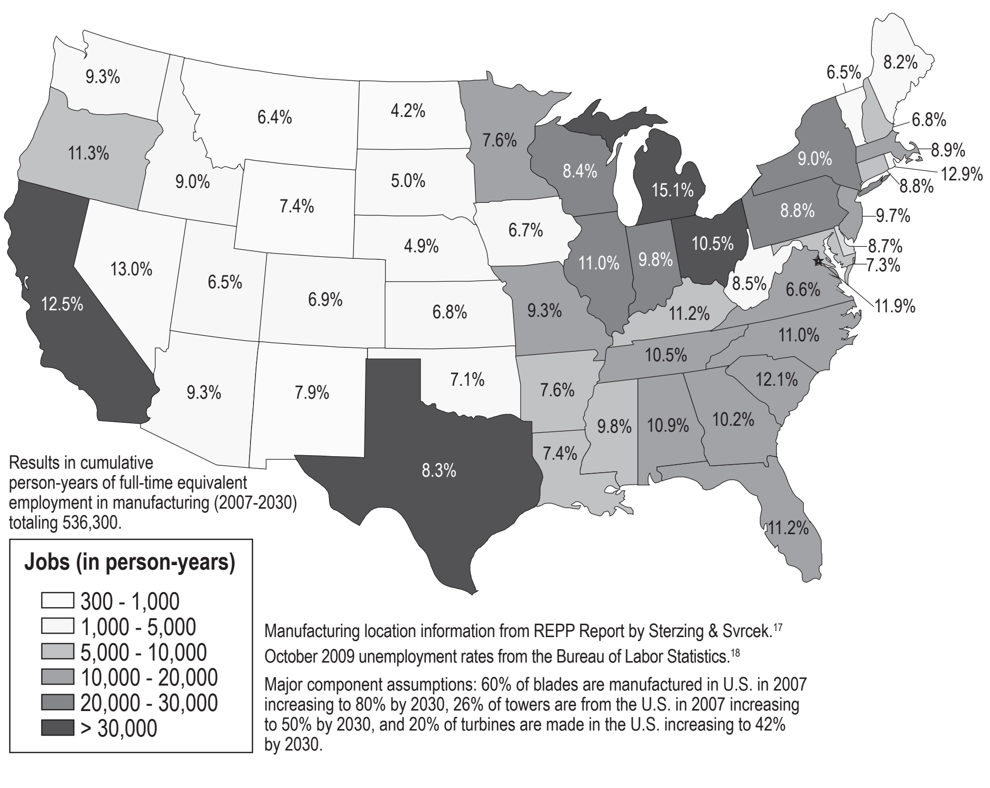
Carbon capture and storage (i.e., capturing and storing carbon from the burning of fossil fuels) has relatively small employment impacts. Currently, there are uncertainties in commercial viability, technology, and regulation (see Table 1).[14]

In recent studies, the wind industry generates more jobs than the coal, gas, and nuclear power industry per megawatt hour generated. In Europe, which has been a leader in wind energy, over 60,000 jobs have been created in the last 5 years. This job growth averages 33 new people every day, seven days a week.[15]

To meet a 20% wind energy target, Wisconsin would create 20,000 to 30,000 jobs between 2007 and 2030.

The U.S. currently employs about 50,000 people in wind energy. According to the U.S. Department of Energy, meeting a goal of 20% wind energy by 2030 will add 260,000 jobs per year. Between 2007 and 2030, that adds 6 million jobs in the construction phase and another 3 million jobs in the operation phase.[16] For example, in Wisconsin, 20,000 to 30,000 jobs would be created between 2007 and 2030. Importantly, these manufacturing jobs would be created and located in many areas hard hit with unemployment (see Figure 1).

Figure 1. Potential manufacturing jobs needed to fulfill the 20% wind energy target by 2030 per state (the darker the color on the map, the more jobs), compared to the U.S. seasonally adjusted rate of unemployment per state.



Four large wind farms were recently constructed in Washington State. According to the Renewable Northwest Project, they are creating hundreds of new jobs and generating millions of dollars in new property tax revenue and millions more in royalties paid to landowners.[19]

Investments in energy efficiency also have positive and immediate economic benefits. For every million dollars invested in energy efficiency, 13 FTE (full-time-equivalent) jobs are created from direct installation and production of the materials alone. What's more, the energy savings that result increase disposable income, which also creates jobs. For example, in a 2008 study, between 1972 and 2006, households had added disposable income of $56 billion from their energy savings. These savings translated into 1.5 million FTE jobs with a total payroll of $45 billion.[20]

What Steps Have States Taken to Move Toward a Clean Energy Economy?

Renewable energy can drive both economic development and employment.

Renewable energy can be a driver for both economic development and employment. The best place for states to start depends upon taking stock of their existing resources whether it be natural resources (e.g., sunlight, wind, or fertile soil), industrial resources (e.g., advanced manufacturing industries or skilled workforces), or intellectual resources (universities or national laboratories).[21] States with abundant clean energy resources such as wind or solar can benefit from commercializing the technology to utilize these resources. Even in the absence of natural resources, states with strong industrial and intellectual resources can contribute to clean energy development.

Selected examples of pioneering states are given below. For a complete listing, see the 2008 report of the National Governors Association Task Force, *Securing a Clean Energy Future*, chaired by Governor Tim Pawlenty and former Governor Kathleen Sebelius.[22]

California

California 2006 Global Warming Solutions Act (AB32) calls for greenhouse gas emissions to be cut to 1990 levels by 2020, a 25% reduction. AB32 is part of a longer-term state plan that Governor Arnold Schwarzenegger enacted to reduce emissions by 80% below 1990 levels by 2050. The benefit of this program lies, not only in reducing greenhouse gases, but also in providing the impetus for technological innovation. This program links a number of state initiatives—solar thermal and solar photovoltaic (PV) technologies, new "zero energy" residential and commercial building standards, and combined heat and power systems.

California, Connecticut, Florida, Illinois, Massachusetts, Minnesota, New Jersey, New York, and Wisconsin

These nine states currently have allocated funds to clean energy research, development, and demonstration (RD&D). States raise money to support clean energy investments in several ways—using public funds, adding surcharges to utility bills, raising funds directly from ratepayers, etc.

Massachusetts

The Massachusetts Renewable Energy Trust is a quasi-public body, established by the state and funded by ratepayers. Each residential customer pays about 50¢ per month. Massachusetts was the one of the first states to implement such an approach to fund clean energy initiatives. A small group of ratepayers challenged the legality of the funding mechanism, but the Massachusetts Supreme Judicial Court ruled unanimously in favor of it. The Trust provides financial support to early stage firms and to those not sufficiently developed to attract private funding. The Trust also works to attract venture capital funds to Massachusetts and to shift the focus toward longer-term investments.

In Massachusetts, residential customers pay about 50¢ per month to fund clean energy initiatives.

Michigan

The 21st Century Jobs Fund is a 10-year, $2 billion initiative to diversify Michigan's economy. Funded mainly by securitized tobacco settlement funds, the first round of awards provided $126.3 million to 78 organizations doing high-tech research, commercializing new products, and creating new jobs in four main sectors, including alternative energy.

Minnesota

Minnesota has developed technology to convert manure to electricity using anaerobic digesters. Commercial viability is exemplified by a demonstration project at Haubenschild Dairy Farm with assistance from the Minnesota Department of Agriculture, the University of Minnesota, and the nonprofit Minnesota Project.

Ohio

Ohio's Third Frontier Project was initiated in 2002 to expand the state's high-tech research capabilities. Over 10 years, $1.6 billion is allocated to build research capacity, support early-stage capital formation, and finance advanced manufacturing technologies. One beneficiary of this state program, the University of Toledo, has become a leading center for research and development of thin-film, solar technology. Numerous companies that were previously automotive industry suppliers have benefited such as the Xunlight Corporation, which develops thin-film coatings to lessen glare on automotive windshield glass.

What Steps Can States Take to Build an Independent and Secure Energy Future?

Apart from allocating funds, states can contribute in other ways to support clean energy initiatives. States can capitalize on funding by venture capitalists. For example, in 2007, venture capitalists invested over $2.2 billion in more than 200 clean technology deals, a 340% increase from 2005. States can "prime the pump" for private investment in energy research in several ways, six of which are mentioned here.

(1) States can allocate funds to energy research, which makes private investments more likely to follow.[23]

(2) States can commit to ambitious, long-term energy targets. For example, Renewable Portfolio Standards (RPS) signal to investors that new technologies will be needed to meet the government target.[24]

(3) Plans can be made to provide access to and expansion of the infrastructure for electricity transmission.[25]

(4) Streamlined planning and permitting procedures can be put in place.[26]

(5) States can improve college and university training in the skills needed by leading-edge firms.[27]

(6) One of the biggest levers that policymakers have for attracting private investment is ensuring consistent policies relevant to the financial horizon of venture capitalists (i.e., private funding in equity capital in early stage companies).[28]

Overall, to ensure the best chance for success, public policy needs to have continuity, predictability, and reliability that signals government is serious about supporting clean energy. The energy industry requires substantial investments of tens of millions of dollars for demonstration projects in which state-of-the-art technology is constantly improving. The development time for new technologies can range from 5 to 10 years and up to 30 years. When companies can rely on consistent energy and environmental policies, they are willing to make the robust and long-term investments that are needed because they believe they can profit from the clean energy revolution.[29]

Based on studies of innovations, several successful policies have been identified for investing in clean energy. Some of these powerful policy tools have a small price tag.

Standards

Standards are one low-cost way to encourage the adoption of clean energy technologies.

Standards are one way to encourage the adoption of clean technologies. Standards are legal or regulatory criteria to meet a certain defined performance or criteria. They can be enacted at low cost to the state and are sometimes more politically palatable than a tax. Standards can evolve over time depending on how the technology develops.

Renewable Portfolio Standards (RPS)

Renewable Portfolio Standards mandate that a certain percentage of electricity generation come from renewable sources, which usually increase over time. More than half of states have some type of RPS with standards as high as 30% by 2020. Wisconsin requirements vary by utility with a 10% goal by 2015.

Low-Carbon Fuel Standards (LCFS)

These standards require that fuel providers meet a declining amount of greenhouse gas emissions per unit of fuel sold. For example, in California, by 2020, the LCFS will produce a 10% reduction in the carbon content of all passenger vehicle fuels sold in the state.

Lighting Efficiency Standards

Minimum standards for the efficiency of electric lighting installed in new buildings could jumpstart the development and application of this technology.

Tax Credits and Taxes

Tax credits have the advantage of being easier to enact, whereas taxes have the advantage of raising revenue. Tax credits can be based on capital investment in the energy system (investment tax credits) or the energy produced by the system (production tax credits). The credits can be applied to property taxes (29 states), income taxes (24 states), and sales taxes (22 states).

Two tax approaches attempt to reduce carbon emissions by putting a dollar value on them. The carbon tax penalizes high carbon emitters and rewards low emitters. "Cap and trade" programs create a system whereby emission rights for carbon (or other pollutants) are limited and can be traded. No state has yet enacted a carbon tax, but several municipalities are in the process of doing so. For example, Boulder, Colorado will tax its residents based on the amount of electricity consumed by businesses and homeowners. The tax will generate about $1 million annually that will be used to fund energy efficiency programs and educational outreach.

Incentives and Subsidies

Incentives and subsidies incur greater implementation costs to the state but may be more politically acceptable. For example, several states including Arizona, California, Florida, New Jersey, New York, Tennessee, Utah, and Virginia have passed laws or are piloting efforts to open up carpool lanes to hybrid cars or, in some cases, to any car with fuel efficiency greater than 45 miles per gallon.

Enabling Markets

States can change regulations and infrastructure to promote clean energy. For example, net metering can allow customers to sell electricity back to the grid, thereby encouraging residential consumers to install renewable energy systems. States can also provide consumer education such as ensuring widespread availability of "carbon footprint" analysis. For example, if consumers see two brands of toothpaste, one with a good and one with a bad carbon score, they have the option of making a low-carbon choice. Our laboratory has developed a carbon calculator, which is being used by the state of California to help consumers make carbon-conscious decisions (see http://coolclimate.berkeley.edu/).

States can provide consumer education by making "carbon footprint" analysis widely available.

Collaboration Among Industry, Academia, and Government

New energy industries require a scientific advance coupled with supply chains, industrial relationships, and higher education to collectively move scientific advances into practice. Many successful examples exist of states facilitating these kinds of partnerships including Oregon's proposed National Wave Energy Research and Demonstration Center, Connecticut's Global Fuel Cell Center, and North Carolina's Advanced Transportation Energy Center. Sometimes a state's role is mostly informational and administrative; at other times, states provide a substantial portion of the funding, facilities, personnel, and other resources. In each case, the university's existing strengths (e.g., electro-chemical and battery research at the North Carolina Center) are recognized and promoted by state government. All else being equal, a clean energy RD&D project is more likely to succeed if it can leverage established expertise, rather than starting from scratch.

Cooperation Between States or Regions

In some cases, the best approach for a state is communication, coordination, and collaboration with its neighbors to capture the full benefits of natural resources that extend across a region. For example, states sharing high-potential wind resources may wish to pool resources not only for RD&D but also for transmission lines and other infrastructure. Several states have a utility-funded RD&D organization. The Energy Center of Wisconsin is one example.

Measurement of Success

Evaluation of the impact of past investment decisions is an important step for making future investment decisions. Markers of success could include patents filed, jobs created, new businesses formed, existing businesses expanded, pollutants reduced, and so forth. States can also calculate the economic value of the jobs and businesses created, as well as the energy saved.

Summary

To encourage private investment, public policy needs to have continuity, predictability, and reliability that signals government is serious about supporting clean energy.

Clean energy technologies can boost state and regional economies, and create clean jobs. Based on recent evidence, the renewable energy sector generates more jobs per unit of energy than the fossil fuel sector.[30, 31]

However, investing smartly in clean energy is difficult. More than many industries, the clean energy sector demands long time frames and sizeable capital investments. To encourage private investment, public policy needs to have continuity, predictability, and reliability that signals government is serious about supporting clean energy, conservation, and energy efficiency. States should seek to implement a portfolio of projects with the greatest potential payoffs including energy efficiency, renewable energy, nuclear power generation, and clean fossil fuels.[32]

Policymakers and industry leaders can help place the economy back on track by committing to long-term, low-carbon solutions. By so doing, policymakers can decouple economic growth from emissions growth.[33] Clean energy policy has the potential to be one of those rare “win-win” policies that can drive both economic development and employment.

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his knowledge of economic, policy, and health impacts. He has worked with the National Governors Association on energy policy and testified over 30 times before Congress and several state legislatures including Connecticut, Florida, Minnesota, and New York. Kammen advises the African Academy of Sciences, the American Academy of Arts and Sciences, the President's Committee on Science and Technology, the United States and Swedish Agencies for International Development, and the World Bank. Kammen has been a guest on National Public Radio's Science Friday and has been interviewed by CNN and numerous local television and radio stations on energy, environment, and policy issues.
Dr. Kammen is married and has one daughter.

This chapter was adapted from the following articles available from the Wisconsin Family Impact Seminars in their entirety.

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Clean Energy Economy Glossary

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Cap and trade

Program that reduces emissions of pollutants flexibly and at a lower cost than more prescriptive types of environmental regulation. The cap sets a limit on the total amount of emissions allowed in a year. The trading aspect of the program means that not all entities have to reduce emissions by the same amount. Businesses that are able to reduce emissions cheaply can over-comply and sell emissions permits to businesses for which reducing emissions is more expensive.

Carbon capture and storage

Technology that captures the greenhouse gas carbon dioxide (CO2) from the burning of fossil fuels at power plants, and buries it underground or undersea. The technology exists but has not yet been deployed at commercial scale.

Carbon footprint

The amount of greenhouse gases (GHG) that are emitted into the atmosphere each year by an entity such as a person, household, building, organization, or company. It is usually measured in units of carbon dioxide equivalents. The carbon footprint of an average American is about 20 tons per year, 10 for a European, and 5 for a Chinese.

Carbon tax

Emissions of carbon are taxed based on the amount emitted. All carbon emitters pay the tax creating incentives to reduce emissions. The tax generates government revenue which can be used in many ways, such as reducing income taxes, investing in clean technology, or for other types of programs.

Clean energy

A broad term that includes several strategies designed to have a low impact on the environment such as renewable energy sources; clean, nonrenewable energy technologies; efficiency technologies; and advanced energy storage technologies.[1]

Fossil fuels

Fossil fuels are the nation's principal source of energy. The popularity of these fuels is largely due to their low costs. Fossil fuels come in three major forms—coal, oil, and natural gas. Because fossil fuels are a finite resource and cannot be replenished once they are extracted and burned, they are not considered renewable.[2]

Greenhouse gases

Gases like carbon dioxide, methane, nitrous oxide, ozone, and water vapor naturally occur in the earth's atmosphere. Human activities can increase concentrations, notably through fossil fuel combustion to produce heat, transportation, and electricity. These gases are dubbed greenhouse gases because they remain in the atmosphere and intensify the sun's heat as it radiates from the earth, similar to a greenhouse's glass walls heating the air inside of it.[3]

Emissions
Emissions are gases and particles released into the air as byproducts of a natural or man-made process.[4]

GWh
Gigawatt hour. An amount of electricity, which is equal to one million kilowatt hours or one thousand megawatt hours. A small spaceheater running for 1 hour consumes about 1 kilowatt hour of electricity.

Low-carbon fuel standards
Standards that require that fuel providers meet a specified, and sometimes declining, amount of greenhouse gas emissions per unit of fuel sold.[5]

Net metering
Arrangement that permits residential customers or a facility (using a meter that reads inflows and outflows of electricity) to sell any excess power it generates over its own requirements back to the electrical grid to offset consumption. This encourages residential consumers to install renewable energy systems.[6, 7]

Non-fossil fuels
Energy sources that can never be completely consumed such as solar power, geothermal, wind, tidal power, biomass, wave power, hydropower, and ocean thermal gradients.[8]

Renewable Portfolio Standards (RPS)
Renewable energy mandates in the United States requiring that a certain percentage of overall electric power come from renewable sources such as wind, solar, biomass, and geothermal by a specified date. Also referred to as Renewable Energy Portfolios (RNP). For example, Wisconsin is required to derive 10% of the electricity it uses from renewables by 2015.[9]

Person-years
A unit of measurement based on an ideal amount of work done by one person in a year consisting of a standard number of person-days.[10]

RD&D
Research, development, and demonstration.[11]

Smart Grid
The Smart Grid is a modernized transmission and distribution infrastructure for electricity that communicates pricing, supply, and demand information to consumers in real time and allows for more efficient purchasing, selling, and use of power. It also allows better monitoring of the system to detect and avoid outages.[12]

Solar PV

Photovoltaic panels that convert sunlight directly into electricity. PV is made from semiconductor materials, and does not create any pollution, noise, or other impacts on the environment. Homes and businesses may incorporate solar panels and arrays as a source of clean energy.[13]

Supercapacitors

A very high-capacity energy storage system consisting of two parallel conductive plates separated by a dielectric material. The electric energy is stored as an electrostatic field between the plates by the electric charges accumulated on the plates.[14]

Venture Capital (VC)

Startup or growth equity capital or loan capital provided by private investors (the venture capitalists) or specialized financial institutions (development finance houses or venture capital firms).[15]

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