Preface for a Comprehensive Energy System Plan.

Conservation of Energy.

Society's first obigation is to not squander resources, especially the "free" resources provided by nature; and to produce resources that sustain its continued existence. Conservation of existing resources is the place to start. Water conservation, tree preservation, existing stream and drainage system respect and other resource protection and presevation ethics and actions are important. Buckminster Fuller opined that Nature or The Creator gave us a resource base sufficient to hold us over until we could figure out how to be self sustaining. Seems the time for self sufficiency is fast approaching.

The law of conservation of energy states that energy can neither be created nor destroyed - only converted from one form of energy to another. Heretofore, coal and oil have been our primary sources of electrical energy. The current trauma is to switch primary source of energy to renewable sources. We can convert wind, solar and hydro power into mechanical or electric energy. The challenge of our times is to use renewable energy sources, namely wind, solar and hydro, to create useful energy – electricity.
LINK:
https://energyeducation.ca/encyclopedia/Law_of_conservation_of_energy

Energy conservation is a great way to reduce the demands to create energy, or transform one source of energy into another [see sidebar]. The primary conservation activities to reduce energy consumption are the ones that use energy directly, i.e., vehicles and homes. Secondary conservation activities are those that reduce wastes that demand an energy-intensive response, i.e., the generation of green house gases. There must be tertiary activites, but concentration on the most visible ones seems prudent. The many ongoing and creative ideating and experimentation confound cataloguing. A few are mentioned below.

A Vision of the Global Energy System.

A vision of a system of the sources and users of energy helps organize the progress of each individual component of the system and it describes one way in which each component might fit into a unified, cohesive system. The basic idea, described in more detail below, seems to be:

The entire system will be based on electricity; the challenge is how to best produce and distribute electricity for the five user groups.

The Primary System: To build an electricity production system based on renewable sources - wind, solar and geothermal.

The Support System: To have a secure Support System for the Primary Systems when the sun does not shine and the wind does not blow; the Support System can be nuclear.

The Legacy System: Oil, gas and coal will remain essential sources of electricity production until secure Primary and Secondary Systems are established.

The Transition Plan is critical. The Legacy Systems cannot be abandoned until their replacements are functioning. Development of the new and sustainable Primary and Secondary Systems is, or should be, the priority to enable a timely transition.

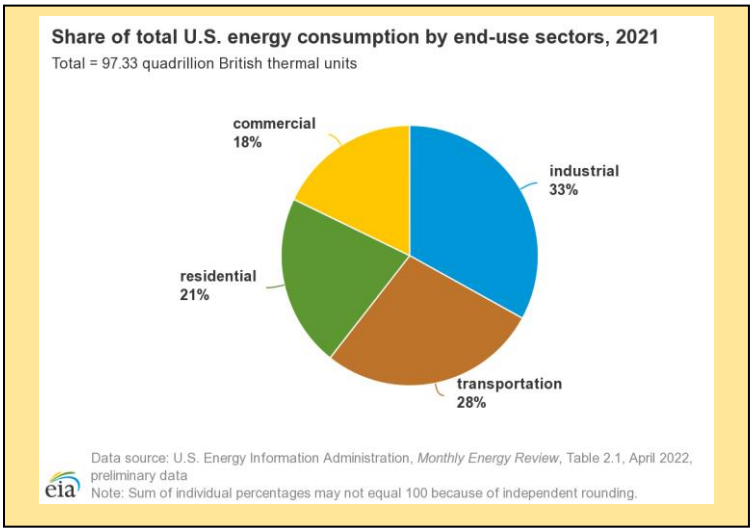
Energy User Groups.

The generators of greenhouse gases can be found in five user groups [EIA]. The chart shows the four major categories of energy consumption.

Transportation (27% of greenhouse gas emissions; 28% of energy consumption) – The transportation sector generates the largest share of greenhouse gas emissions. Greenhouse gas emissions from transportation primarily come from burning fossil fuel for our cars, trucks, ships, trains, and planes. Over 90% of the fuel used for transportation is petroleum based, which includes primarily gasoline and diesel. EVs will help; hydrogen for vehicles will help; more efficient vehicle engines will help.

Electricity production (25% of greenhouse gas emissions) – Electricity production generates the second largest share of greenhouse gas emissions. Approximately 60% of our electricity comes from burning fossil fuels, mostly coal and natural gas.

Industry (24% of greenhouse gas emissions; 33% of energy consumption) – Greenhouse gas emissions from industry primarily come from burning fossil fuels for energy, as well as greenhouse gas emissions from certain chemical reactions necessary to produce goods from raw materials.



Commercial and Residential (13% of greenhouse gas emissions; 39% of energy consumption) – Greenhouse gas emissions from businesses and homes arise primarily from fossil fuels burned for heat, the use of certain products that contain greenhouse gases, and the handling of waste.

Agriculture (11% of greenhouse gas emissions) – Greenhouse gas emissions from agriculture come from livestock such as cows, agricultural soils, and rice production.

Land Use and Forestry (13% of greenhouse gas emissions) forms a unique sixth group – Land areas can act as a sink (absorbing CO_2 from the atmosphere) or a source of greenhouse gas emissions. In the United States, since 1990, managed forests and other lands are a net sink, i.e., they have absorbed more CO_2 from the atmosphere than they emit.

The Energy Conservation Case for Saving Existing Buildings

As Einstein has demonstrated, energy is stored in mass. Energy, therefore, is stored in the mass of built structures; in the wood, concrete, steel, plastic and other materials. Saving existing buildings has a twofold energy savings: the first is saving the energy embodied in the structure itself. The second is the energy saving from not having to reproduce the structure with its materials plus the energy required for the equipment, materials, financing and disposal of waste. Buildings that cannot be saved and redeveloped can be recycled through salvage of materials in the demolished building. Existing buildings are energy; treat them accordingly.

Sources of Electrical Generation.

The five predominant users of energy listed above share sources of energy, but each user group also has traits that lend themselves to rely on some specific sources more than others. The trick, or the goal, is to match the features of each energy user group with each source of energy to ensure the most efficient system for connecting energy users and energy generators.

The mixing and matching of users and generators is complicated, but the results will be worth the clarification efforts. Add in the continuous stream of new methods and processes for generating energy and the picture adds a few more dimensions.
The sources for energy generation for electricity production, listed in the sidebar, include all known sources, except hydrogen. Hydrogen has been targeted as a source of energy for transportation as a complement to electricity for EVs.

Electric Generation Energy Sources 2020

- **Natural Gas:** about 40% - of U.S. electricity generation in 2020.
- **Nuclear:** about 20% of U.S. electricity generation in 2020.
- **Coal:** the third-largest energy source for U.S. electricity generation in 2020 - about 19%.
- **Petroleum:** less than 1% of U.S. electricity generation in 2020.
- **Renewables:** the source of about 20% of total U.S. electricity generation in 2020.
  - **wind:** 8.4%
  - **hydroelectric:** 7.3%
  - **solar:** 2.3%
  - **biomass:** 1.4%
  - **geothermal:** 0.5%

Source: EIA.gov

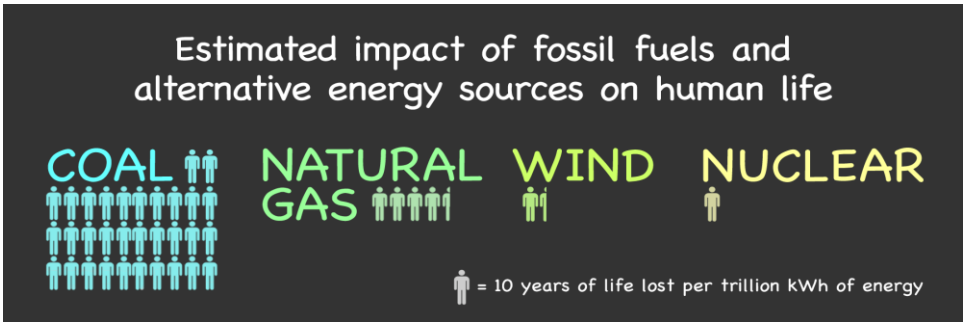
EXCERPT FROM...

SITN science in the news celebrating 20 years

HARVARD UNIVERSITY
The Graduate School of Arts and Sciences

Reconsidering The Risks Of Nuclear Power

OCTOBER 25, 2016
by Jordan Wilkerson, figures by Shannon McArdel
"The figure is based on estimates from Europe Union, which account for immediate deaths from accidents and projected deaths from exposure to pollutants."



LINK: https://sitn.hms.harvard.edu/flash/2016/reconsidering-risks-nuclear-power/

The Primary System of Electricity Production in the Near Future.

The Primary System of Electricity Production in the near future must be based on renewable sources - wind, solar and geothermal. With hydroelectric and biomass playing their part. Wind and solar sources are the main sources to rely on in the future for the bulk of the Primary System to produce electricity. Advances in technology, reduction of costs and the installation of facilities bode well for the future. How quickly we get there is the challenge.

SOLAR [2.3% of national electricity production].

- **Power companies** are investing in solar farms.
- **Community solar** refers to moderately large solar projects — usually up to 5 megawatts — that a number of customers, which can include individuals, organizations and companies, subscribe to or jointly own. Instead of putting panels on their own roof or property, a community solar participant taps into the value of a solar system located elsewhere, like on a community center or in a field. The projects, also called community solar gardens or farms, generate energy that's fed into the grid.
- **Individual solar installations** such as solar roofs for parking fields makes great sense for energy production using unused air space complemented by the weather protection benefits. Individual homes with solar panels are using the generated electricity directly and some are contributing their electricity back to the grid, sometimes for rebates.
- **Solar panel scale, cost and production** are ensnared in global trade, supply chain and material availability issues; all resolvable when the will strikes those in control.

WIND [8.4% of national electricity production].Wind power is created in low population areas that are not the major consumers of electricity. Wind turbines are located on land and water. Connecting wind turbines in the Midwest and offshore to the national electric grid is the work to be done.

- The environmental impacts still demand resolution.

HYDROELECTRIC POWER [7.3% of national electricity production].

- A little discussed source of electricity production, but famous for its association with TVA and the major dams in the United States.
- One suspects that the technology for squeezing more and more production from existing sources will transpire incrementally, but that the places where hydroelectric power can be generated are fixed and therefore not a great source of extraordinary growth as a contributor to the electricity production system.

How many homes can an average wind turbine power?

According to the U.S. Energy Information Administration, the average U.S. home uses 893 kilowatt-hours (kWh) of electricity per month. Per the U.S. Wind Turbine Database, the mean capacity of wind turbines that achieved commercial operations in 2020 is 2.75 megawatts (MW). At a 42% capacity factor (i.e., the average among recently built wind turbines in the United States, per the 2021 edition of the U.S. Department of Energy's Land-Based Wind Market Report*), that average turbine would generate over 843,000 kWh per month—enough for more than 940 average U.S. homes.*

To put it another way, the average wind turbine that came online in 2020 generates enough electricity in just 46 minutes to power an average U.S. home for one month.

LINK: https://www.usgs.gov/faqs/how-many-homes-can-average-wind-turbine-power

BIOMASS [1.4%] and **GEOTHERMAL [**0.5%] are not well understood by the author. To the extent they can grow as contributors to the global electricity production system, the better.
HYDROGEN, the redheaded stepchild of the energy portfolio is making a statement. Hydrogen is proving a great, near-term alternative source of power for transportation vehicles, especially over-the-road trucks. Truck stops are adding hydrogen to their re-fueling offerings as are municipalities for their fleets. Hydrogen may become a great alternative to the alternative electric vehicles.

The Support System of Electricity Production from Renewable Sources.

The Primary Systems need support. Solar and wind power need a reliable complementary source of energy to fill the voids created when the sun does not shine and the wind does not blow. Nuclear fits the bill. Nuclear power already provides about 20% of US energy in 2020. Hydrogen, geothermal, biomass and hydroelectric systems can contribute specific applications within the overall system.

Nuclear power comes with baggage. Nuclear disasters and the disposal of nuclear waste are both significant issues. The challenge is to address these issues rather than discarding the nuclear option. The argument in favor of continuing to perfect nuclear power as the support system for wind and solar is:

- Technology is evolving; smaller, modular reactors are replacing the aging first generation power plants; Europe is developing new options that do not rely on Russian imports.
- SMRs, small modular reactors, have many enhancements and advantages.
    - They are smaller which means they are less expensive.
    - They can be permitted and constructed faster than first generation plants.
    - They generate less waste. They can be Support System generators with wind and solar bearing the brunt of the demand function.
        - SMRs are modular. This means they can be constructed in a factory with better quality.
        - Modular units can be replicated at many sites, reducing costs and increasing reliability.
- Re-use of spent rods is being accomplished in France and other advanced nations. The application of these techniques worldwide is just a matter of time.

Conclusions.

1. **Match each energy use with its natural energy source.** Trucks may use hydrogen; homes may use geothermal; don't presuppose one source fits all needs.
2. **However, in the main, the vast majority of users in the near term will rely on the production and distribution of electricity.**
    - ♦ The Primary System for electricity production in the near future can be wind and solar.
    - ♦ The Secondary System for calm and dark times can be nuclear, geothermal or hydrogen.
3. **The National Electric Grid needs to be enhanced, connected and secured.**
4. **Small communities can make a difference.** For example, **The City of Iowa City, Iowa** has taken climate change seriously. The City's "Climate Action Plan" uses a simple yet effective system for evaluating actions to improve conditions; the system provides a balance of effectiveness and cost. As the chart below from ***Planning Magazine,*** April 2019 indicates, some low-cost actions have high climate improvement impacts; some high cost options are not that effective.

TAKING ACTION: IOWA CITY'S CAP

The Iowa City Climate Action Plan identifies 35 action items crucial to meeting the city's emissions reduction goals. The table below summarizes the action categories and lists the actions designated as high priority. In addition to the plan, the city created a Climate Action Toolkit that is meant to inspire the community to take an active role in reducing the city's greenhouse gas emissions. The toolkit is available online at icgov.org/climateaction.

BUILDINGS | TRANSPORTATION | WASTE | ADAPTATION | SUSTAINABLE LIFESTYLE

ACTION	SECTOR(S) HOME/WORK/GOV'T	COST	LOCAL GREENHOUSE GAS IMPACT
BUILDINGS			
Increase energy efficiency in residences		$-$$$	
Increase energy efficiency in businesses		$-$$$	
Increase energy efficiency in new buildings		$	
Increase on-site renewable energy systems and electrification		$$	
Continue to increase energy efficiency in city-owned buildings		$-$$$	
TRANSPORTATION			
Increase use of public transit systems		$-$$$	
Embrace electric vehicles, alternative fuel vehicles, and other emerging technologies		$$	
Increase bicycle and pedestrian transportation		$	
Increase compact and contiguous development		$$	
Increase employee commuter options		$	
WASTE			
Reduce waste at the source		$	
Take action on a study to efficiently capture and use methane from wastewater operations		$	
Take action on a feasibility study on energy generation from landfill methane		$$$	
ADAPTATION			
Develop communications and outreach plan for vulnerable populations		$	
Coordinate extreme weather preparedness planning with local agencies		$	
SUSTAINABLE LIFESTYLE			
Encourage a plant-rich diet*		$	
Create funding mechanisms to support community-wide climate action		$$$	
Incorporate this Climate Plan into the city's sustainability communications		$	

* While the immediate impact on emissions in Iowa City may be relatively small, the global impacts related to eating more plants and less meat result in a very high impact.

4 **Planning** April 2019

LINK: https://www.icgov.org/project/climate-action