2) Identify Options for Zero GHG Emissions;

INTRODUCTION

We all were born and raised in the unsustainable oil & gas frame of reference. That's all we've ever known. Therefore, it is difficult to think outside that box and identify what options are available.

Fortunately, the grace of the Universe combined with the curiosity and cleverness of homo sapiens has provided sustainable options to burning oil & gas. We are living in an era of the 'perfect storm' caused by the current ecocidal behavior of humans; we are simultaneously living in an era of the 'perfect solution.' That path we take is our choice.

We have everything we need to further compromise the habitability of our planet and usher in the sixth mass extinction; we also have everything we need to transition to a way of living that is in right relations with our finite planet and its interdependent web of life. It is our choice.

What are some sustainable options for burning ancient hydrocarbons as a source of energy?

What alternative energy sources are in right relations with our finite planet?

Finite Planet. The quantities of ancient hydrocarbons are finite. Children being born today will live to see the practical end of fossil fuels. We will stop burning this resource and associated GHG emissions will go to zero in less than 100 years unless we transition to other forms of energy. That's math, not science. (Question: Wonder if Congress denies subtraction also?) (Of course, extracting and burning all the carbon on the planet would be repeating the Venus experiment – and we know how well that turned out for living systems).

Depending on the audience, there might be resource material in the Unabridged Version of the First Universalist Case Study that could be used to help explain various forms of energy and the ancient hydrocarbon drawdown. See Appendix A.

Molecular Physics. Complex combinations of atoms (greater than diatomic molecules – more than two atoms) have the ability to absorb electromagnetic energy in the infrared portion of the spectrum. Most (99.9%) of the atmosphere is comprised of N_2, O_2, and Argon (non-greenhouse gases). Although only a small amount (0.1%) of the atmosphere is H_2O, CH_4, NO_x, etc. (greenhouse gases), these more complex molecules have a significant effect on the energy balance of the Earth and therefore an effect on all living systems.

Mass Collaboration. Our discovery of fire and this source of thermal energy has allowed us to achieve amazing things when we combine technology with mass collaboration. Within our lifetimes we have seen mass cooperation use these ancient hydrocarbons to create the technology needed to allow our species to set foot on the Moon (and bring back some stardust that may have a part of Earth over 4 billion years ago). Within our lifetimes we have seen mass cooperation use these ancient hydrocarbons to create weapons of mass destruction (even extinction) of living species ranging from nuclear bombs to pesticides and herbicides.

But there has always been an invisible cost we were not aware of until this past century – that the combustion of ancient hydrocarbons and the irresponsible release of the resulting combustion waste gases into the atmosphere was altering the chemical composition of our common atmosphere. Within the last century, we have become conscious of the fact that humans are altering the Earth's relationship with its source of life's energy, the Sun, by adding more and more "greenhouse gases" to the atmosphere. As a result, our planet is absorbing more of the Sun's energy and converting it into random chaotic energy we measure as an increase in temperature (of the atmosphere, and of the surface of the land and water in direct contact with the atmosphere) popularized as global warming.

EXPLORATION OF OPTIONS - BRAINSTORMING

Electrical Power

Let's start with electrical power. Today as a buyer, there are several options:

- Buy electrical power from the local utility (e.g. Xcel Energy Corp.) [NO]
  The local 'for-profit' utility generates electrical power using a supply mix of 72% coal and natural gas; and 28 % wind and solar.
- **Harvest your own energy**
  - **Solar PV [YES]**
  - **Wind turbine [NO]**
- **Conserve more. [YES]**
  - Conservation is necessary but not sufficient
    - Conservation must not become a diversion – a smoke screen to make us feel good that we are "doing something."
    - Conservation does not change our unsustainable behavior of burning hydrocarbons if that's all we do.
  - Conservation only makes the transition to renewable energy sources easier
- Do without. ([NO]

Heating and Cooling Choices.

- Buy natural gas from Xcel Energy [and support fracking] and continue to burn fossil fuel.
  - Continue to dump combustion waste into the atmosphere [NO]
  - Pay a third party to "Offset" your waste by planting and managing a forest that matches your rate and duration of CO_2 emissions [NO]
- Buy "Biomass" [recent hydrocarbons such as wood, dried dung, etc. that produce CO_2 emissions] and burn it [NO]
  - Continue to dump combustion waste into the atmosphere [NO]
  - Pay a third party to "Offset" your waste by planting and managing a forest that matches your rate and duration of CO_2 emissions [NO]
- Harvest sunlight and transform sunlight into thermal energy (Solar Thermal) [NO]
  - Excellent for Hot Water
  - Good for radiative heating systems (our home is not equipped for this)
  - Solar thermal cooling is still being developed

- **Exchange thermal energy with the Earth (Ground-source Heat Pumps) [YES]**
    - Excellent for Space Heating and Air Conditioning
        - Ground source heat pumps are also available for both warm and hot water radiative heating systems
    - Good for preheating water with electrical water heater

- **Exchange thermal energy with the Air (Air-source Heat Pump) [Maybe in some cases]**
    - Excellent for moderate climates.
    - Good for preheating water with electrical water heater

- **Conserve [YES]**
  (Insulate, turn down the thermostat, etc.)
    - Conservation is necessary but not sufficient
        - Conservation must not become a diversion to make us feel we are "doing something."
        - Conservation does not change our unsustainable behavior if that's all we do
    - Conservation must be accompanied by a transition to renewable energy sources

- Do without [NO]

OPTIONS SELECTED BY FIRST UNIVERSALIST

Electrical Power Choices

- **Harvest our own energy using rooftop Solar PV [YES]**
    - Had adequate roof space
    - Had no "Historical Preservation" limitations
- **Conserve [YES]**
    - Efficient LED lighting
    - Motion sensitive light switches

Heating and Cooling Choices

- **Exchange thermal energy with the Earth (Ground-source Heat Pumps) [YES]**
    - Excellent for Space Heating and Air Conditioning
        - Ground source heat pumps are also available for both warm and hot water radiative heating systems
    - Good for preheating water to augment electrical water heater

- **Exchange thermal energy with the Air (Air-source Heat Pump) [YES – for DHW]**
    - Excellent for moderate climates.
    - Good for preheating water to augment electrical water heater

- **Conserve [YES]**
    - Added insulation
    - Set back thermostats

Appendix A Graphics

Excerpts from **Unabridged Version** (283 pg, 8.5×11) page 95.

Global Perspective – Energy Resources

From a global science perspective, we ask, "What are the energy sources of Spaceship Earth and how much is there?" helps illustrate what we know about energy resources today.

Since the beginning of the Industrial Era, humans have become fixated on burning ancient hydrocarbons as a primary energy source for doing work. The fixation is most obvious on Wall Street where energy equates to coal, oil, and gas. This narrow concept of energy must be reframed to be able to even see viable alternatives directly in front of us. Marc and Richard Perez developed an interesting graphic using "marbles" to help reframe our concept of energy. As adapted in ***Figure 1 Global Energy Perspective – Types and Quantities of Energy***, the marbles tell a more comprehensive story of "energy."

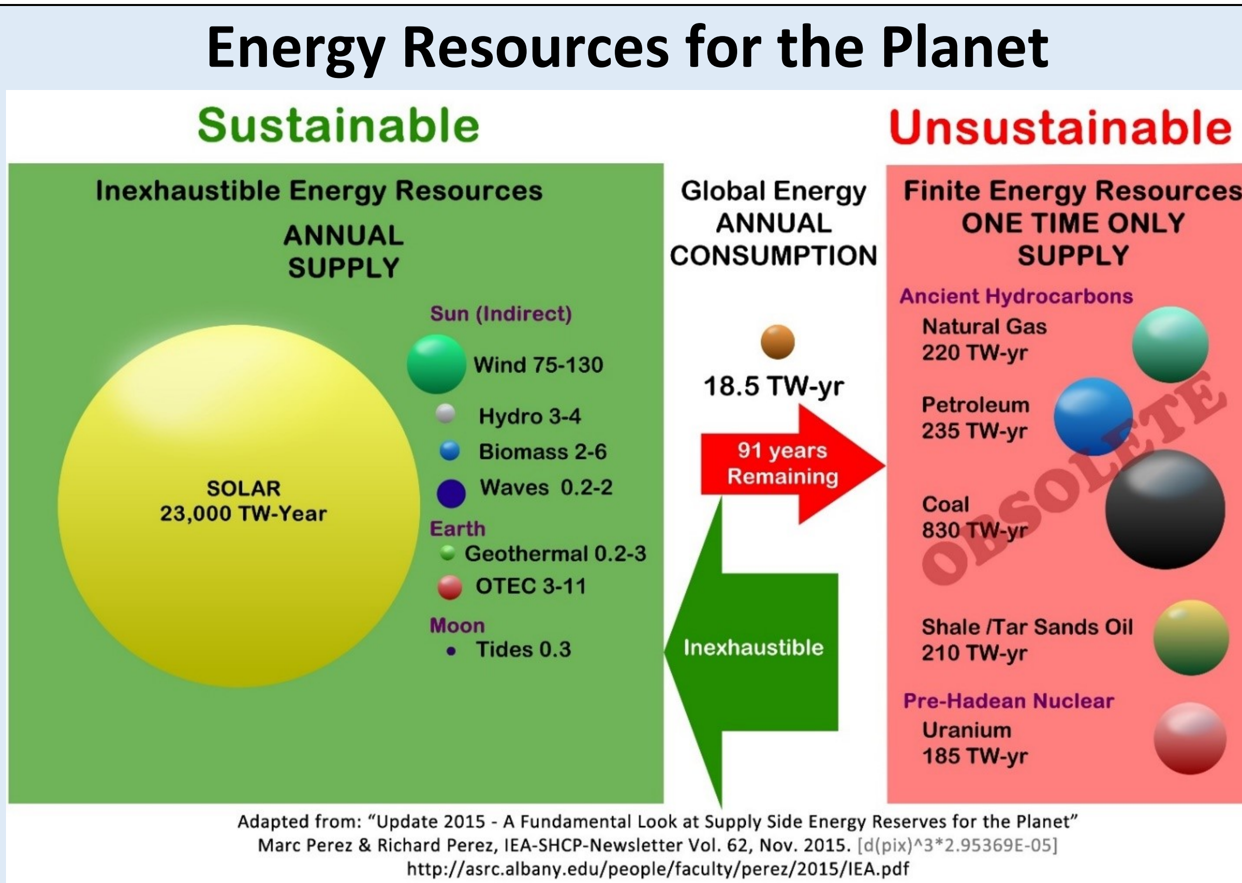

Figure 1 Global Energy Perspective – Types and Quantities of Energy

The colors of the marbles/spheres denote different forms of energy and the size of the sphere relates to the remaining quantity of that type of energy. The five marbles on the right within the red box are the unsustainable (finite) sources of energy remaining on the planet – including fissionable Uranium. The quantities are specified in uncommon energy units: terawatt years (TW-yrs). One TW-yr is 8.765 x 10^{12} kW-hours. Globally, coal remains the single largest amount of ancient hydrocarbons.

The small yellow sphere in the middle white space of the chart represents the amount of energy (18.5 TW-yrs) consumed by the global human community (over 7 billion souls) on an annual basis. If you do the math and add up all the finite energy resources[i] in the red box and divide by the annual global consumption, we find there are roughly **90 years of unsustainable energy remaining** to consume. In other words, children being born today will likely live long enough to see the end of 'fossil fuel' and yellow cake ore (Uranium) during their lifetimes, unless we change our current behavior, now.

Obviously, these dwindling supplies of finite ancient hydrocarbons cannot be considered a sustainable source of energy. **The transition from fossil fuel is inevitable.** The science is obvious (we live on a finite planet); the math is simple.

On the other hand, on the left side of the chart in the green box, sustainable energy sources are identified. These green forms of energy are characterized as inexhaustible and sustainable.

Of course, the dominant feature of this graphic is the large yellow sphere depicting the amount of solar energy incident on land each year. Anyone who says, "without coal and oil, you snowflakes will freeze to death, go hungry and won't be able to see at night because there is not enough solar energy" obviously does not live on planet Earth.

"There would be no life on the planet without the Sun…" Vaclav Smil, "*Energy: A Beginners Guide*." 2006, pg26.

Excerpts from **Unabridged Version** (283 pg, 8.5×11) page 96.

The transition from Fossil Fuel is Inevitable

Figure 2 Transition from Fossil Fuel (Ancient Hydrocarbons) is Inevitable” is another way of

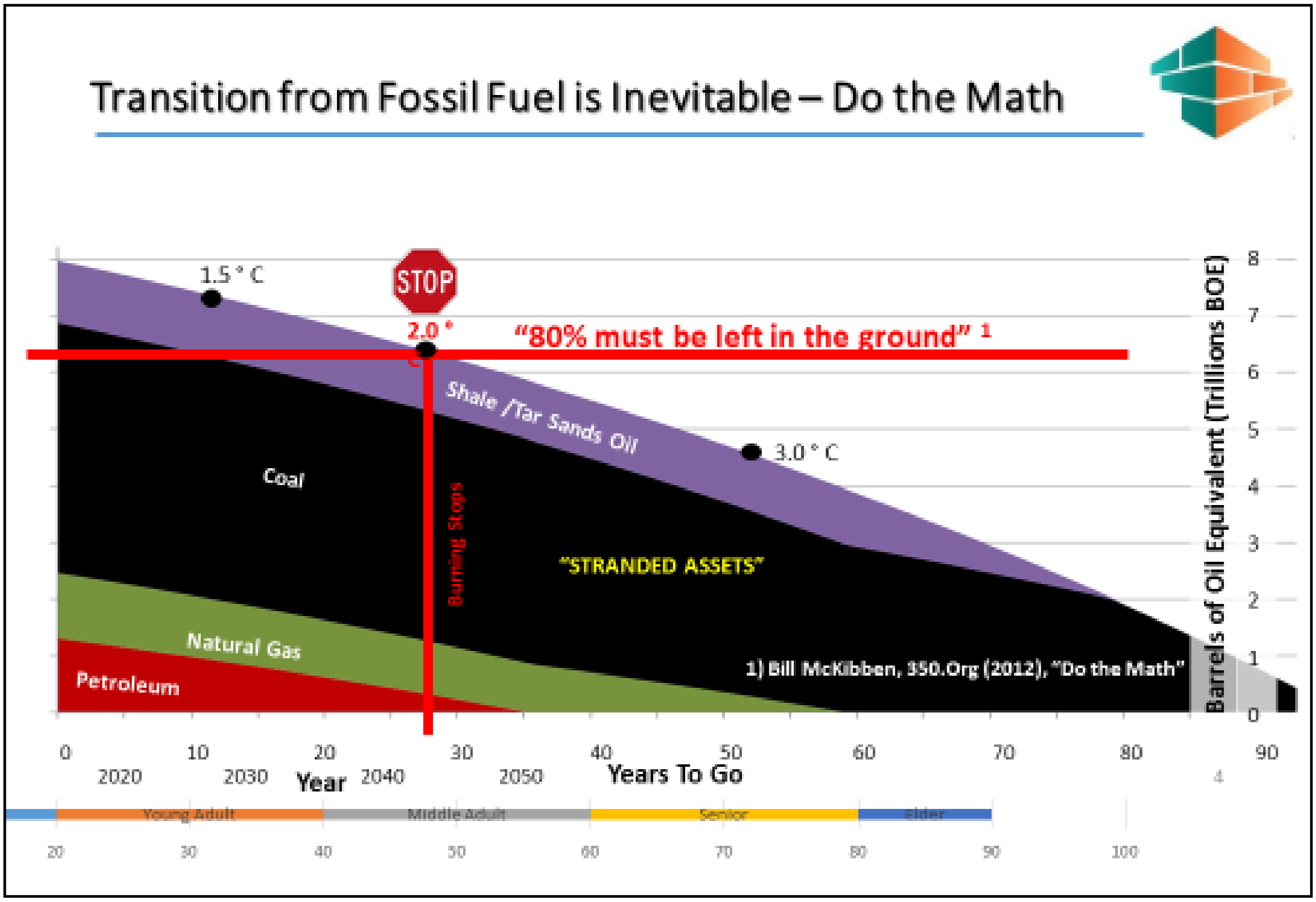

Figure 2 Transition from Fossil Fuel (Ancient Hydrocarbons) is Inevitable

conveying the same idea as Figure 1, but uses a timeline that conveys a sense of urgency for transitioning to inexhaustible sustainable energy. In this graphic, the reserves of ancient hydrocarbons are quantified as barrels of oil equivalent (BOE). The chart shows how these 8 trillion barrels of oil equivalent will be drawn down over time for the next 100 years assuming our current consumption rate plus a 1% annual increase for population growth.

Also shown in this chart are some insights from climate science. In 2012, Bill McKibben, one of the founders of 350.org traveled across the country on his “Do the Math“ tour. Based on the IPCC calculations, McKibben noted that if we continue our current rate of consumption, around the year 2040, all burning of ancient hydrocarbons must stop (as indicated by the red stop sign) if we want to limit global warming to 2°C. He pointed out that to limit global warming to 2°C, we are actually saying “80 % of the known reserves of coal, oil and natural gas must be left in the ground” and labeled as “stranded assets.”

The mere thought of having to write off 80% of their stranded assets must send chills down the spine of ExxonMobil’s management, board, and stockholders. Actually, the outlook for the oil & gas industry is not quite that bad if they just stop being a **fossil fuel burning** industry. A more accurate statement would be “80% of the ancient hydrocarbons in the ground cannot be burned and converted into greenhouse gases.” However, this requires reframing.

There are sustainable uses for these valuable hydrocarbon resources if we stop calling them fossil **fuel** and instead refer to them as ancient hydrocarbons. These hydrocarbons are actually rich sources of precious concentrated carbon that can be used sustainably. For example, they are used as the feedstock for manufacturing recyclable carbon fiber for lightweight materials used in the transportation sector. Instead of burning them, these ancient hydrocarbons can be the feedstock for many types of recyclable plastics (including high-density polyethylene (HDPE) pipe used for circulating water in ground source geothermal heat pump applications and solar thermal heating systems). There are a number of other useful products and non-burning applications for these ancient hydrocarbon resources that do not contribute to global warming.

Before leaving this graphic, we see milestones along the top of the declining curve labeled 1.5°C, 2°C, and 3°C. If we do decide to set our global warming goal at 1.5°C in an effort to save our island nations and coastal cities, we need to make the transition to inexhaustible energy source within the next 10-12 years – before 2030.

Finally, at the bottom of the graphic is a multi-colored strip with numbers representing the lifeline of today's college student. We can see that to limit global warming to 1.5°C, we need to stop all burning when they are 30 years old. We see that to limit warming to 2°C, the "Stop Burning" sign occurs when they are in their 40s. Today's college students will be in their 50s when the remaining petroleum will be too expensive to extract and in their 80s when all that is left is coal, tar sands, and shale oil.

[i] Note: Nature's autotrophic species in the deep past found a clever way to store about one month's worth of sunlight as chemical energy in the form of ancient hydrocarbons/biomass in the Earth's crest. We might ask, how much of the Sun's daily gift of Sun energy have we homo sapiens learned to put aside as a reserve?