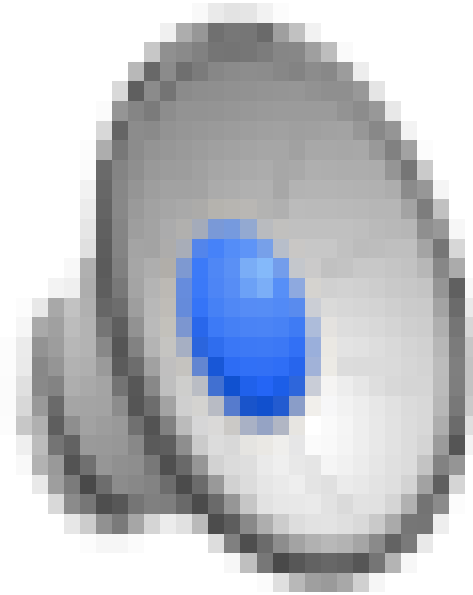


Sustainability : Energy

Imagine an apple as planet earth.....



<https://vimeo.com/128288736>

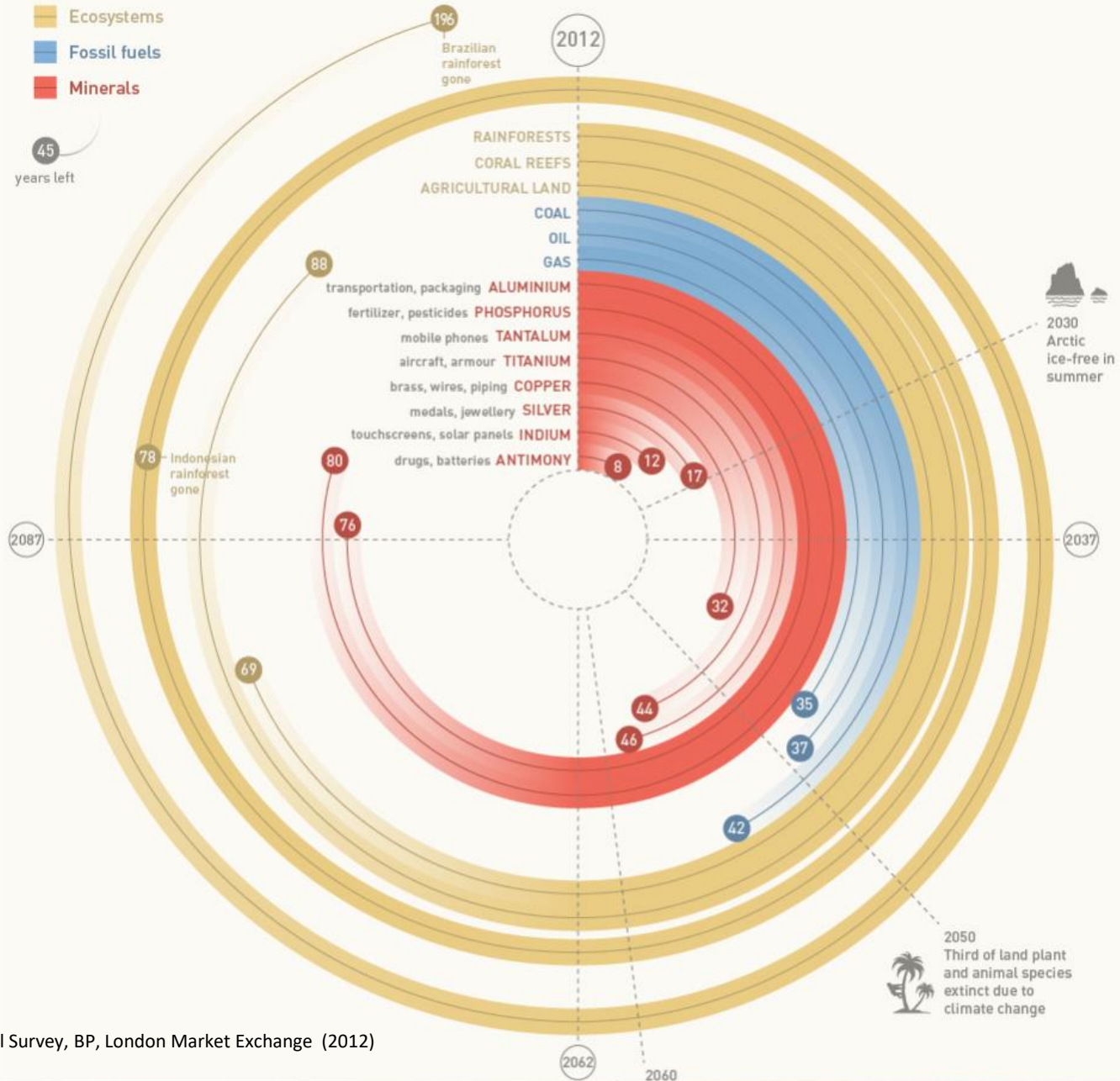
Source: American Farmland Trust

Importance of Sustainability

- 1) Offers solutions that work over a very long period of time.
- 2) Secures food, energy and product needs for future generations.
- 3) Establishes healthy environment for us and future generations.
- 4) Limited time-span on these non-renewable resources.

Stock Check

Estimated remaining world supplies of non-renewable resources



Define
Sustainability???

Sustainability Exercise

- This exercise can be done for all age groups.
- Make a list of words that you associate with sustainability,
 - make your own list
 - One person will collect these words
 - Display these words on board
- Once displayed, everyone can collectively find the words that are common vs. less common.

Let Us See What 'We' think?



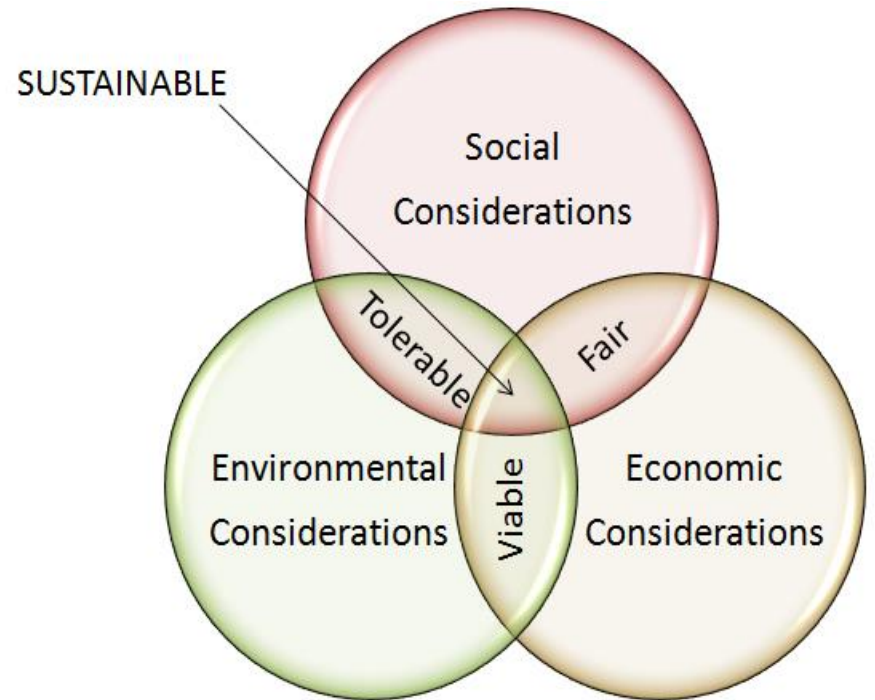
Sustainability Exercise (contd...)

- Purpose of the exercise is show the difficulty as human beings to agree on what should be included or excluded when discussing sustainability.
- Failure to achieve a collective vision of how to attain sustainability lie in the limitations of what we define as Sustainability.

Measuring Sustainability

In measuring *sustainability* of an activity, there are three aspects to consider:

- 1) Economic
- 2) Environmental
- 3) Social





What is sustainability?

Sustainability is the ability to meet the needs of the present generation in ways that also consider and provide for the needs of future generations.

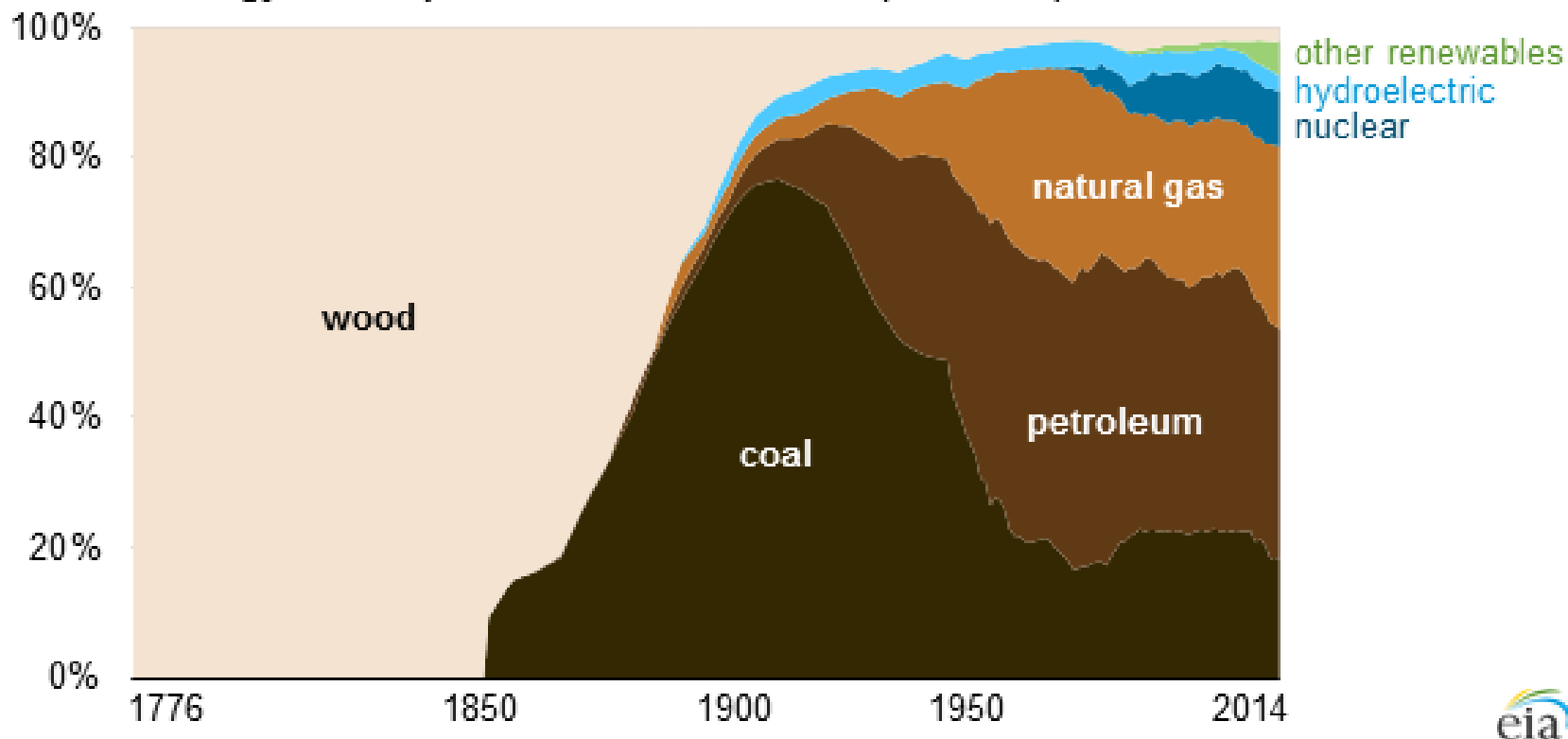
Report of the World Commission on Environment and Development: Our Common Future
Transmitted to the General Assembly as an Annex to document A/42/427 - Development and International Cooperation: Environment 1987

Designing in sustainable ways

- Some resources are available in a limited supply, and some resources are available in a limited, but renewable supply.
- ***Non-renewable, limited resources*** include things such as the amount of land, water, oil, coal, natural gas, and minerals in our accessible resource pool.
- ***Renewable resources*** include things such as plant-based materials, sunlight, wind, geothermal and water-movement (hydro-based) energy.
- Renewable resources are not available in a limitless supply over a short period of time, and are not always available "on demand".

Fossil fuels have made up at least 80% of U.S. fuel mix since 1900

Share of energy consumption in the United States (1776-2014)

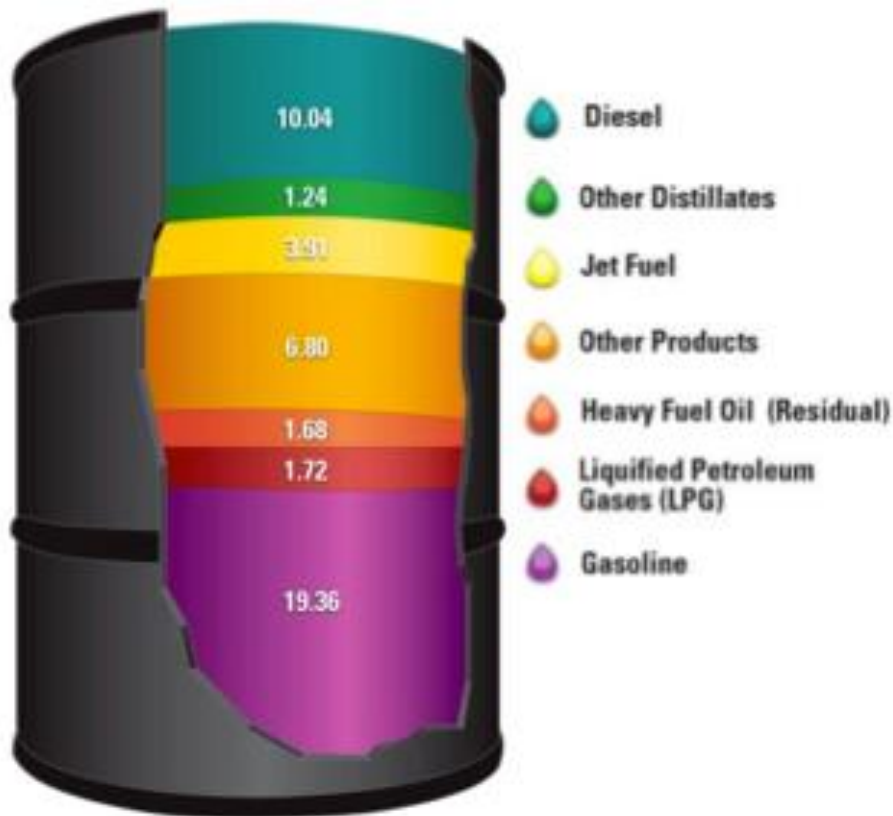


Source: U.S. Energy Information Administration, July 02, 2015, Month Energy Review

Why have alternative fuels?

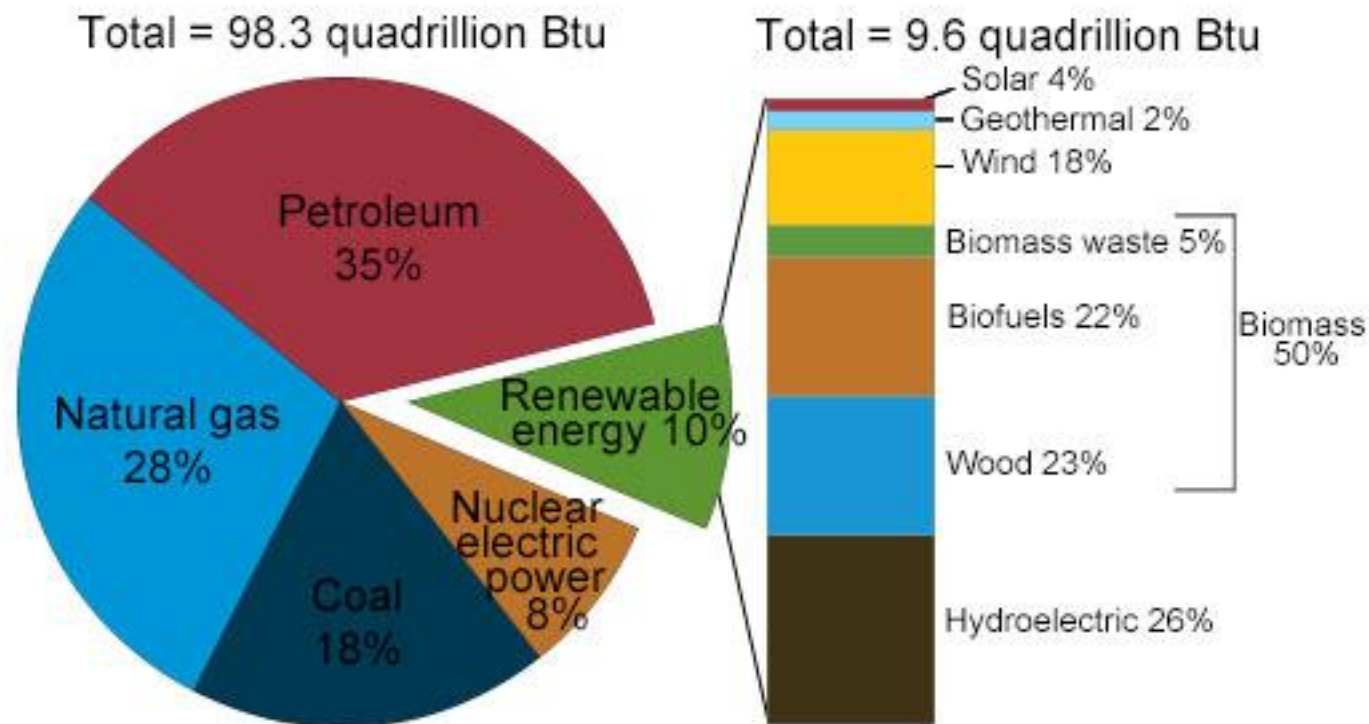
Products Made from a Barrel of Crude Oil (Gallons)

(2009)



- Greater focus needed on R &D for a range of technologies to displace the entire barrel of petroleum crude
- U.S. spends about \$1B each day on crude oil imports*
- Only about 40% of a barrel of crude oil is used to produce petroleum gasoline
- Cellulosic ethanol can displace gasoline fraction
- Reducing dependence on oil requires replacing diesel, jet, heavy distillates, and a range of other chemicals and products

U.S. energy consumption by energy source, 2014



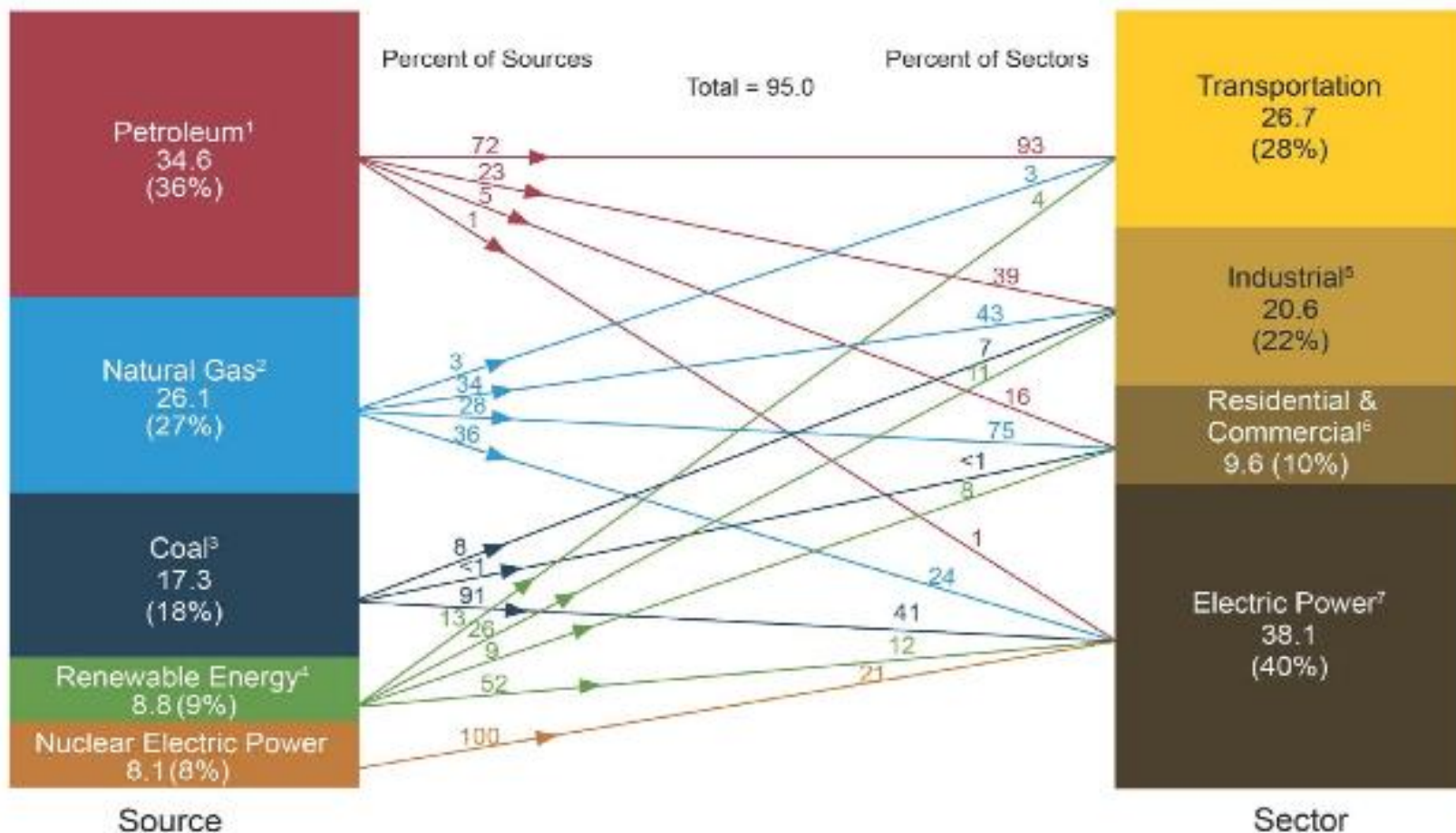
Note: Sum of components may not equal 100% as a result of independent rounding.

Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 1.3 and 10.1 (March 2015), preliminary data



Primary Energy Consumption by Source and Sector, 2012

(Quadrillion Btu)



¹ Does not include biofuels that have been blended with petroleum—biofuels are included in "Renewable Energy."

² Excludes supplemental gaseous fuels.

³ Includes less than 0.1 quadrillion Btu of coal coke net imports.

⁴ Conventional hydroelectric power, geothermal, solar/photovoltaic, wind, and biomass.

⁵ Includes industrial combined-heat-and-power (CHP) and industrial electricity-only plants.

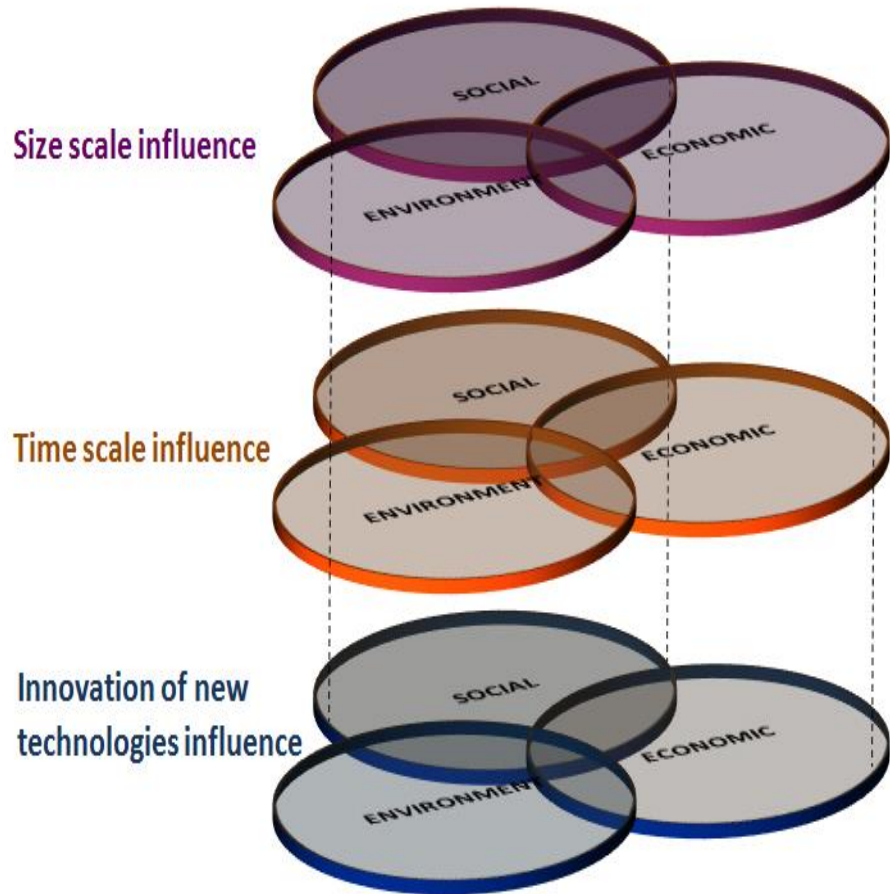
⁶ Includes commercial combined-heat-and-power (CHP) and commercial electricity-only plants.

⁷ Electricity-only and combined-heat-and-power (CHP) plants whose primary business is to sell electricity, or electricity and heat, to the public. Includes 0.2 quadrillion Btu of electricity net imports not shown under "Source."

Notes: Primary energy in the form that it is first accounted for in a statistical energy balance, before any transformation to secondary or tertiary forms of energy (for example, coal is used to generate electricity). • Sum of components may not equal total due to independent rounding.

Sources: U.S. Energy Information Administration, *Monthly Energy Review* (January 2014), Tables 1.3, 2.1-2.6.

Technological Innovation



Technological innovation influences the sustainability of human activities.

Technology has the ability to influence the size scale of our activities.

The influence of time, size scale and technological innovation can be seen as over-arching layers of influence on sustainability.

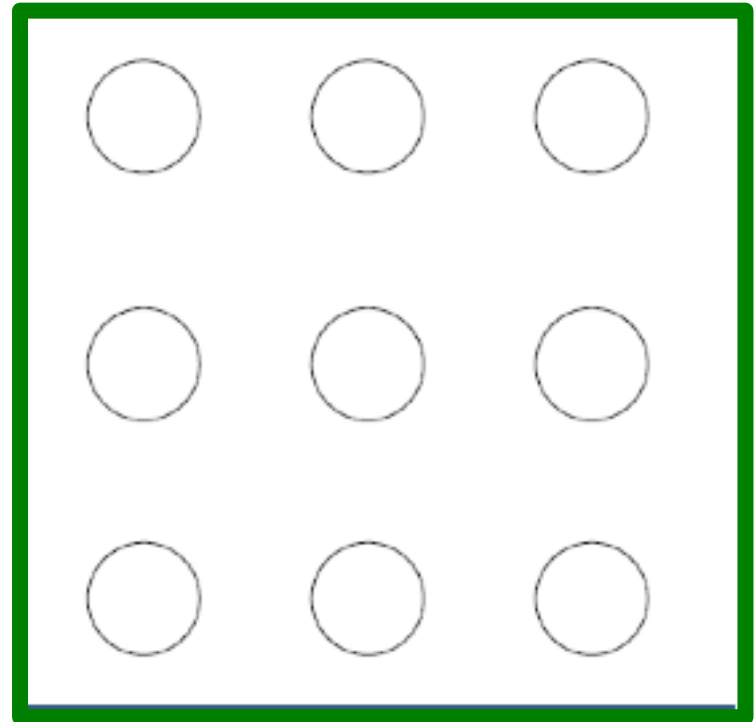
Systems

- Nothing happens in a vacuum
- Domino effect
- The band-aid approach
- Law of Unintended Consequences



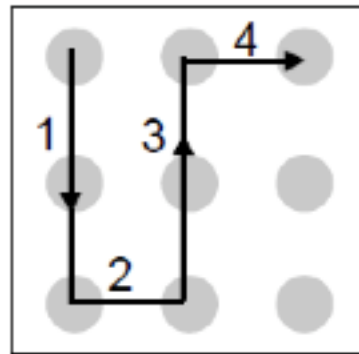
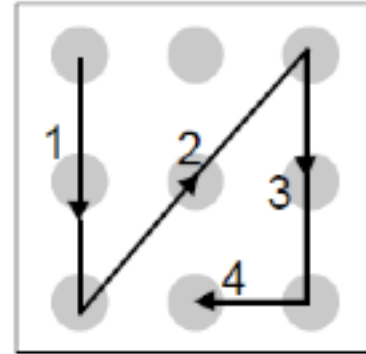
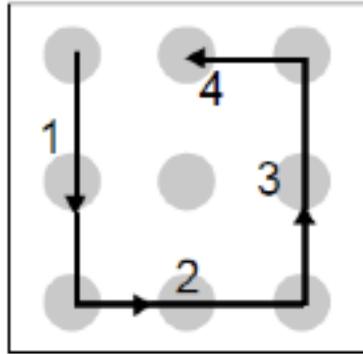
Systems Thinking Activity

Without lifting your pencil from the page, draw 4 or fewer straight lines that connect all 9 circles

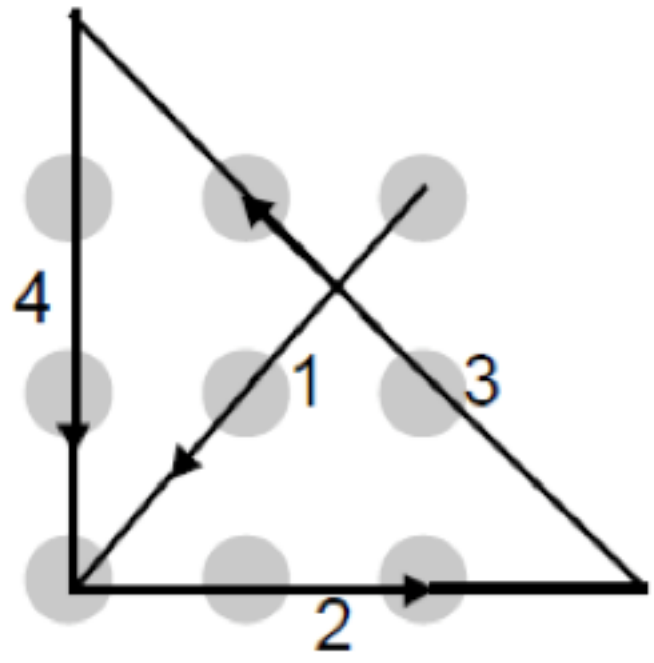


**BOX
APPROACH
TO
SUSTAINABILITY
THINKING**

Did not work?



Preconceived limitations imposed by classical $1+1=2$ thinking?



Additional Influences on Sustainability

- ***Time***

- Time scale, size scale and new innovative technologies all influence sustainability.
- An activity may be sustainable over 50 years, but not over 150 years, or 1000 years.
- Defining the scale of time is an important factor in designing sustainably.

- ***Size***

- Size scale can influence the sustainability of an activity or operation.
- For example, an activity that works well on a laboratory bench or backyard garden scale usually does not 'scale up' to industrial or global scales.
- While it may scale up, it is not without a significant amount of change to the original process.

Sustainability in Bioenergy- Overview

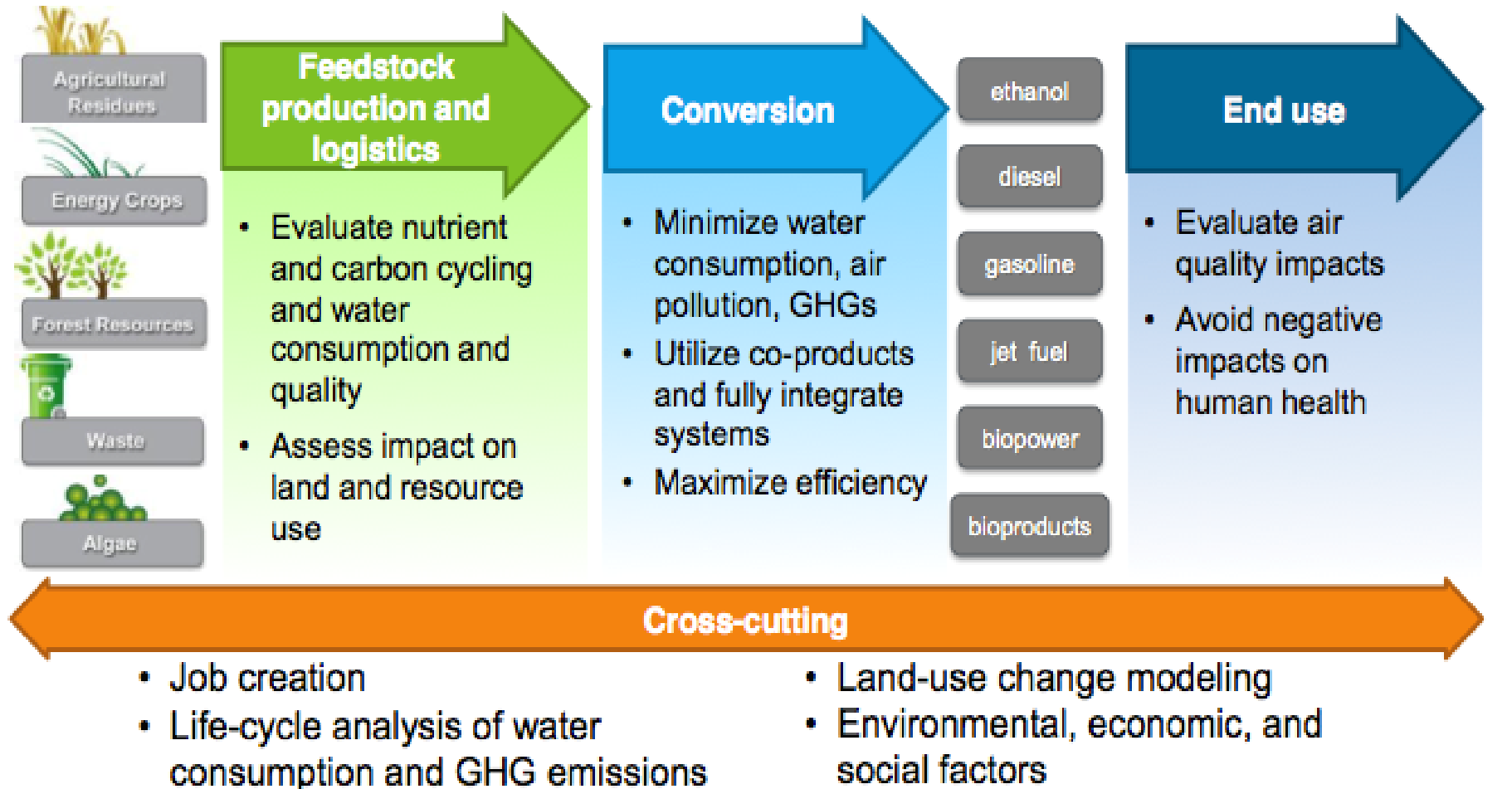


Fig. 1. The fully integrated agro-biofuel-biomaterial-biopower cycle for sustainable technologies.

