

Energy – 10 Big Ideas

What everyone needs to know

1. Could the iron age have preceded the bronze age?
2. What do bicycles have to do with the horrors of the Belgian Congo?
3. What does Rembrandt have to do with peat?

1. Worshipers of The Sun

All Energy Comes From the Sun (almost)

- solar energy – heat and light, photovoltaic effect, concentrating solar
- hydraulic energy – generated by water cycle: evaporation, condensation, precipitation
- wind energy – prevailing winds, diurnal patterns
- biomass – photosynthesis combines water, CO_2 and light energy to form sugars and O_2 ; chemical energy released through combustion and respiration; the basis of the food chain, the purpose of which is to provide energy; carbohydrates
- hydrocarbon energy -- peat, coal, oil, natural gas store chemical energy;
- nuclear energy does not come from the sun (though it powers the sun); nor does tidal energy (which comes from the moon);

2. The Bernoulli Principle Foiled Again

<https://www.youtube.com/watch?v=cLwm2Nlck4>



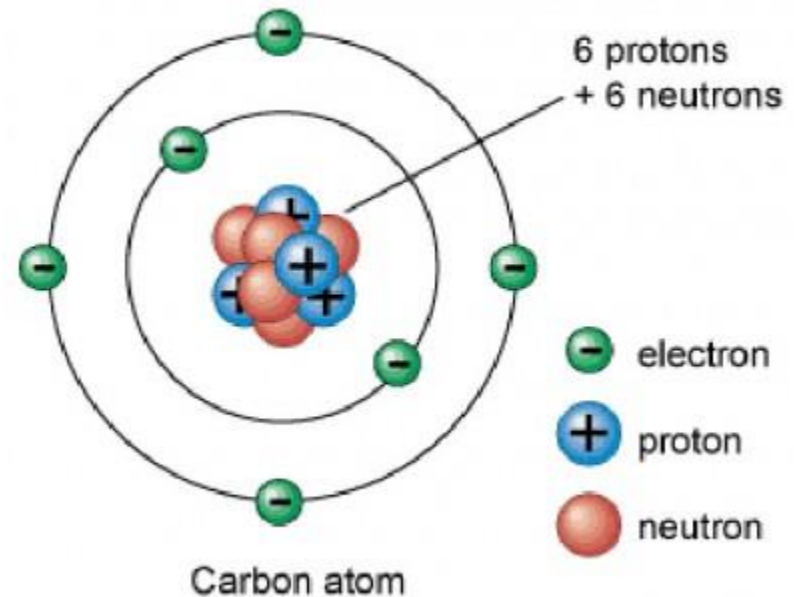
2. The Bernoulli Principle Foiled Again

- Sailing against the wind (you need to come back)
- The first globalization (1500)
- Sailing, flying, wind turbines, (and even helicopters)

3. A Most Gregarious Personality

Carbon

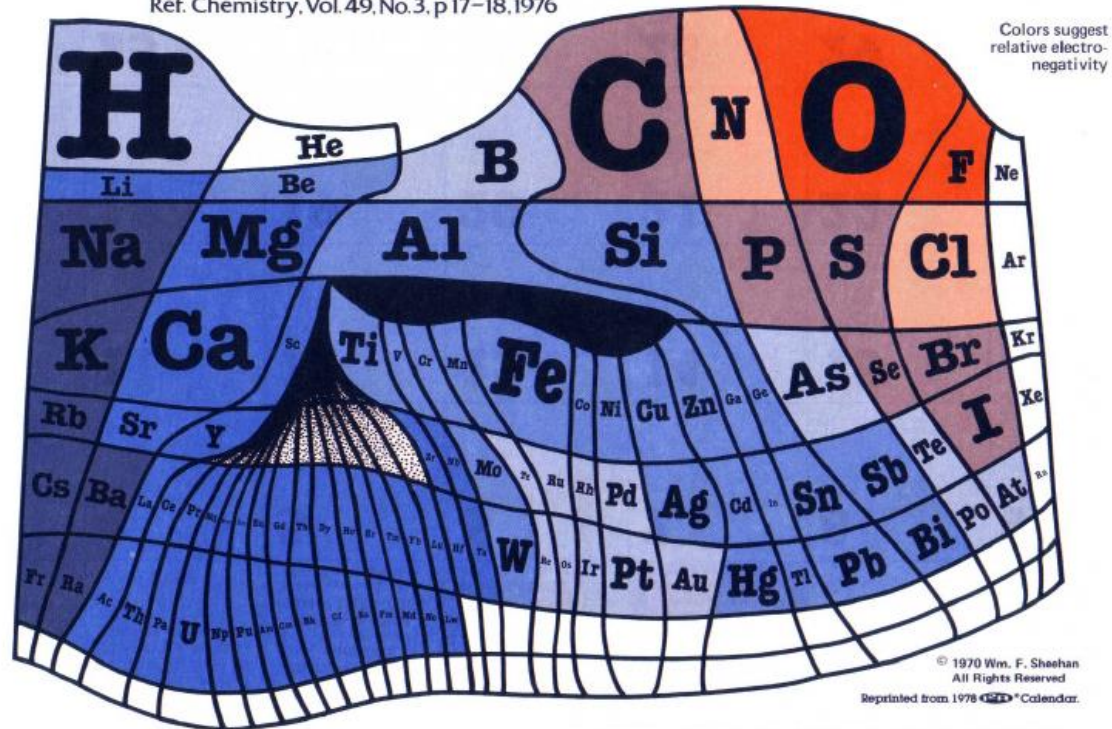
- About 80% of energy that is used world-wide is obtained from carbon-based fuels such as oil, coal and natural gas -- hydrocarbons C_xH_y .
- Life itself is fundamentally dependent for energy on carbon based substances -- sugars, carbohydrates $C_x(H_2O)_y$.
- Why? It forms stable relationships (bonds) easily with other elements and even with itself. Over 90% of known compounds involve carbon. When dissolving bonds it releases energy as it forms new bonds.



Periodic Table

The Elements According to Relative Abundance

A Periodic Chart by Prof. Wm. F. Sheehan, University of Santa Clara, CA 95053
 Ref. Chemistry, Vol. 49, No. 3, p 17-18, 1976



Roughly, the size of an element's own niche ("I almost wrote square") is proportioned to its abundance on Earth's surface, and in addition, certain chemical similarities (e.g., Be and Al, or B and Si) are sug-

gested by the positioning of neighbors. The chart emphasizes that in real life a chemist will probably meet O, Si, Al, . . . and that he better do something about it. Periodic tables based upon elemental abundance would, of course, vary from planet to planet. . . W.F.S.

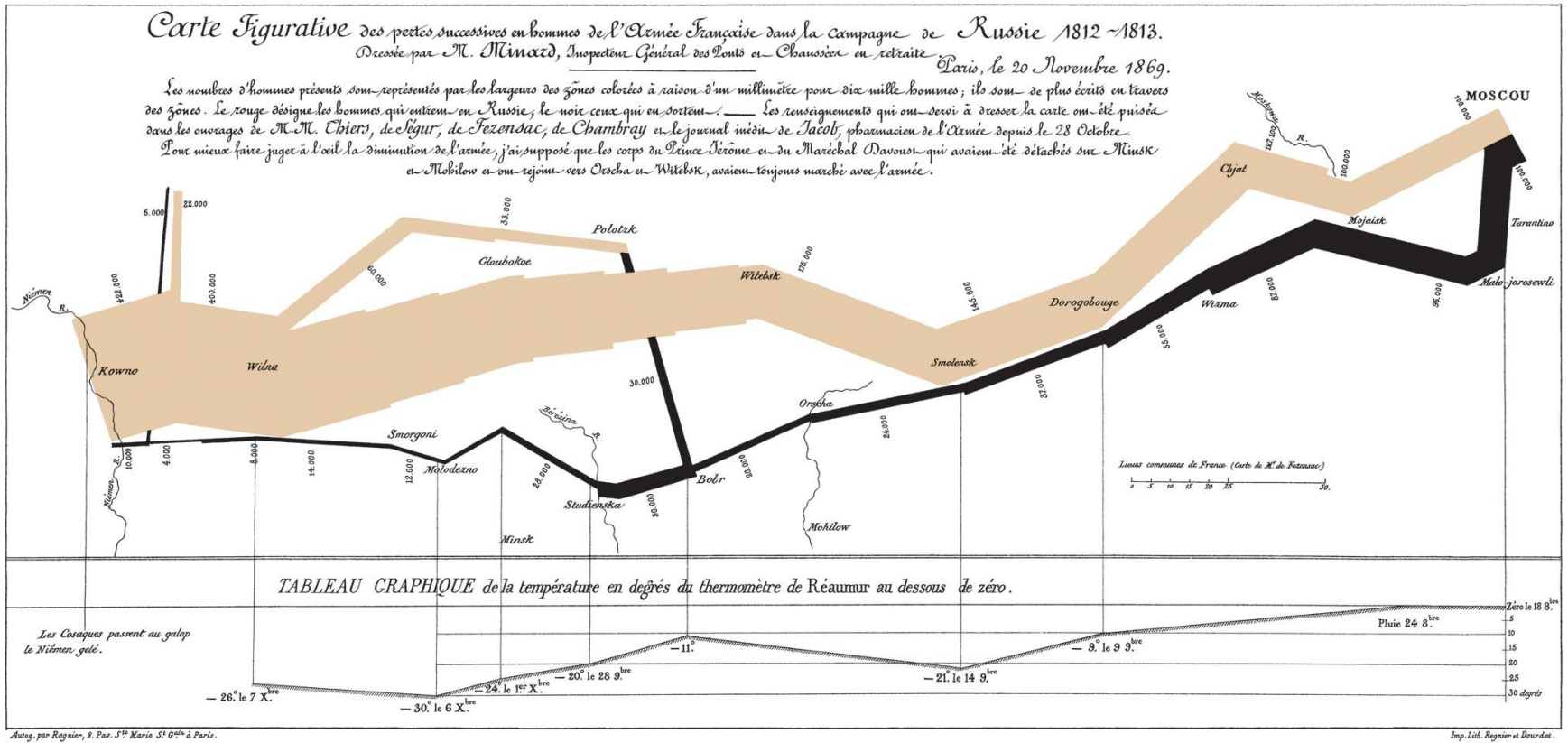
NOTE: TO ACCOMMODATE ALL ELEMENTS SOME DEVIATIONS WERE NECESSARY. FOR EXAMPLE SOME ELEMENTS DO NOT OCCUPY ENTIRE CELLS.

4. Temperature Rising

Controlling Combustion

- Promethean Revolution
- Control of combustion temperatures – permits smelting of metals to make tools, pottery
- Pyrolysis – to make charcoal, coke and extract bitumen
- Distillation and fractional distillation – to separate crude oil into its components (gasoline, diesel, naphtha, lubricants)
- Radiators, stone boiling

5. Napoleon's March

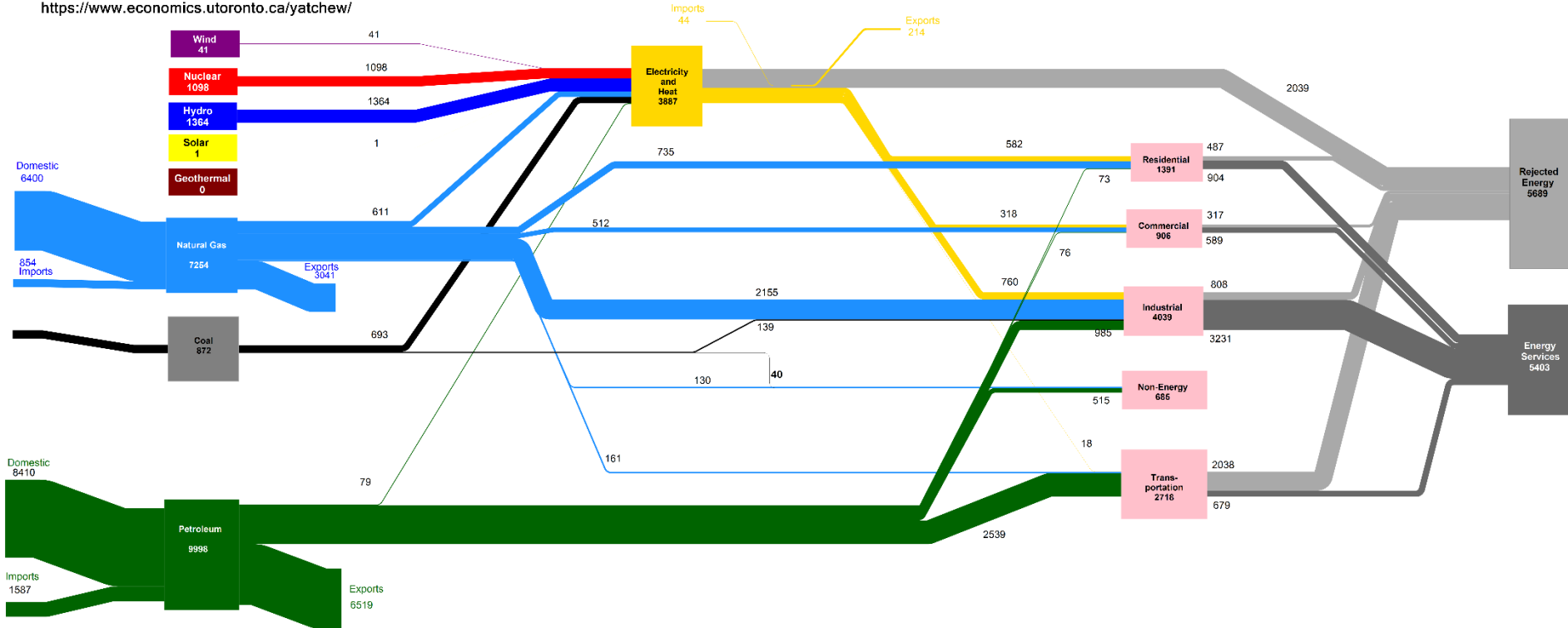


5. Napoleon's March Markets – demand and supply

Canada Energy Flow
in 2014: 20,628 PJ

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<https://www.economics.utoronto.ca/yatchew/>

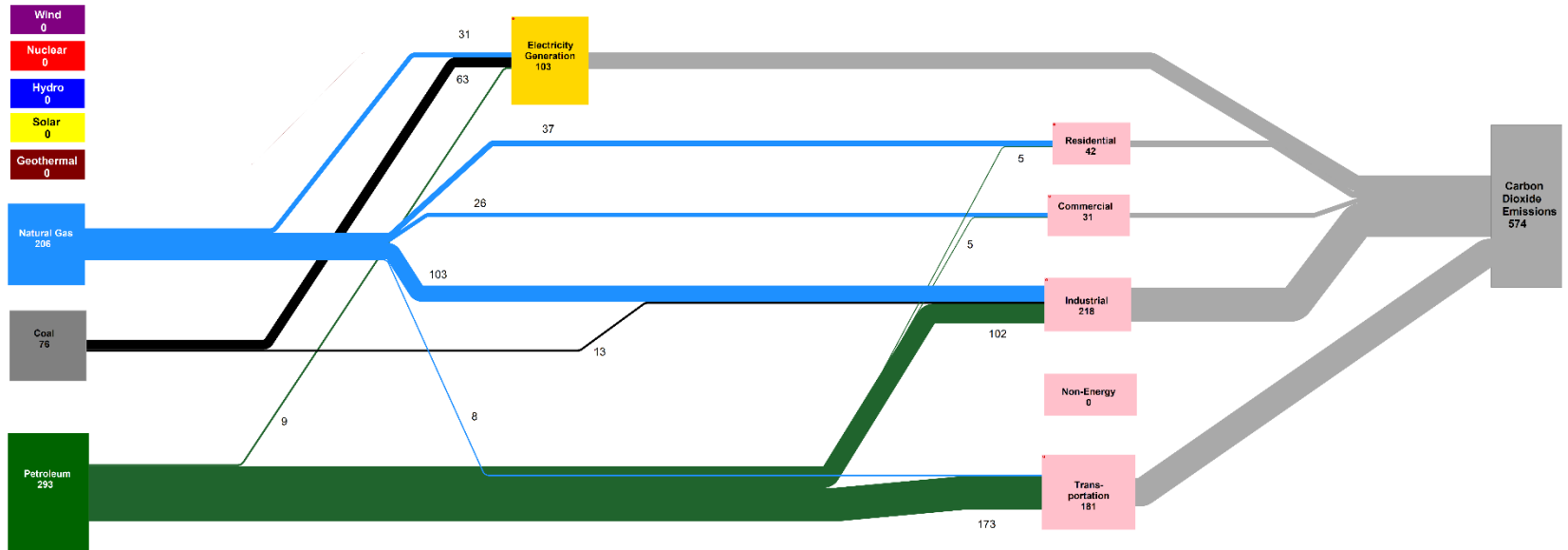


5. Napoleon's March

Carbon flow – sources and destinations

Canada Carbon Flow Emissions
in 2014: 574 Million Metric Tons

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<https://www.economics.utoronto.ca/yatchew/>

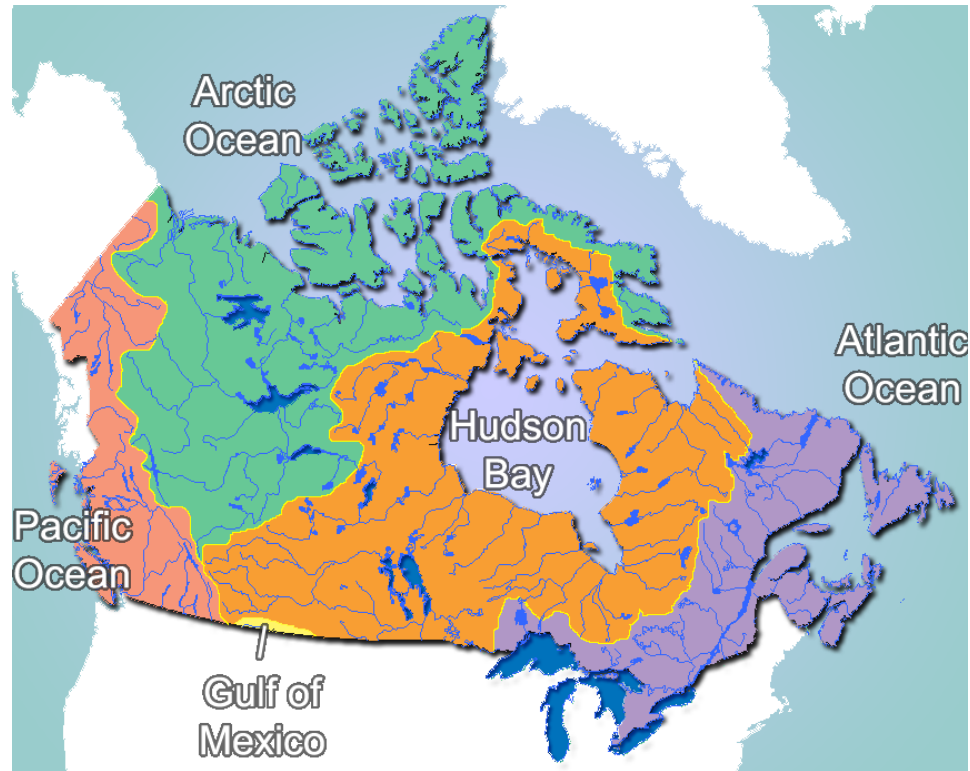


6. Geography and History Matter

Three 'Big' Drivers in Canadian (Energy) History

- Freshwater -- lakes and river systems
- Biomass -- forests
- Hydrocarbons -- coal, oil, natural gas

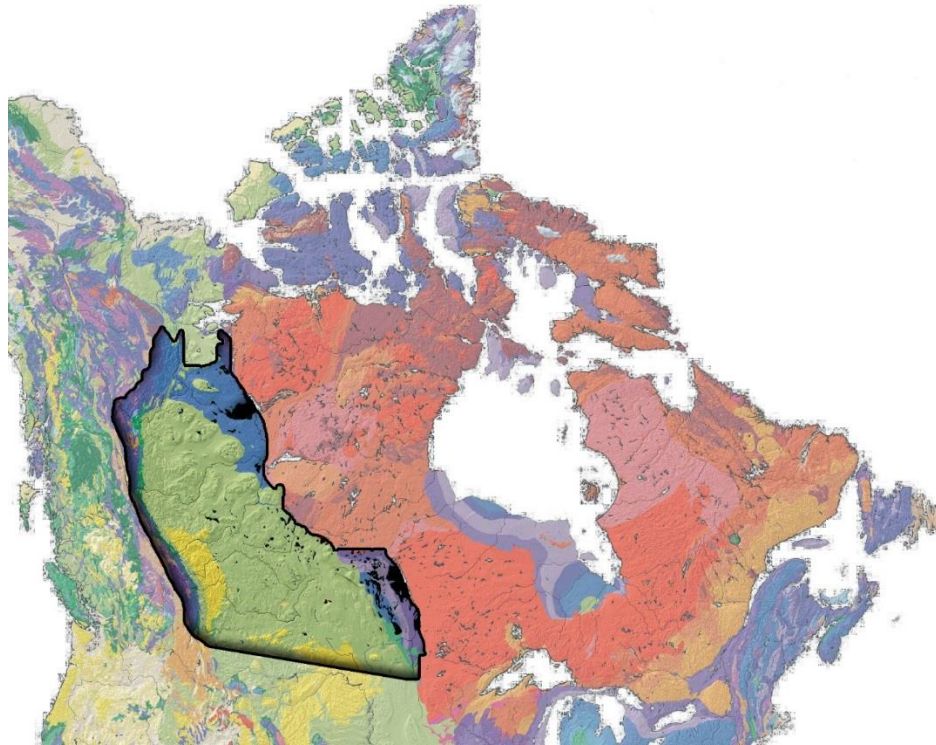
6. Geography and History Matter Watersheds



6. Geography and History Matter

Physical Regions

Western Canadian Sedimentary Basin



7. Institutions Matter

(even more, but which ones???)

- Subsidiarity
 - Decisions should be taken and tasks should be performed at the *lowest* level at which they can competently be decided and completed.
 - The government should undertake responsibilities only if individuals or groups of individuals cannot fulfill them competently on their own

7. Institutions Matter

(even more, but which ones???)

- Separation
 - “The intrinsic tensions created by intertwining policymaking with regulation and implementation are exacerbated in an industry where assets are long-lived. Governments face election pressures, which can result in decisions that at times are driven more by short-term political exigencies than by longer term economic or societal objectives.” How to redeem Ontario’s electricity industry, Adonis Yatchew, Globe and Mail, December 15, 2015.

7 Institutions Matter

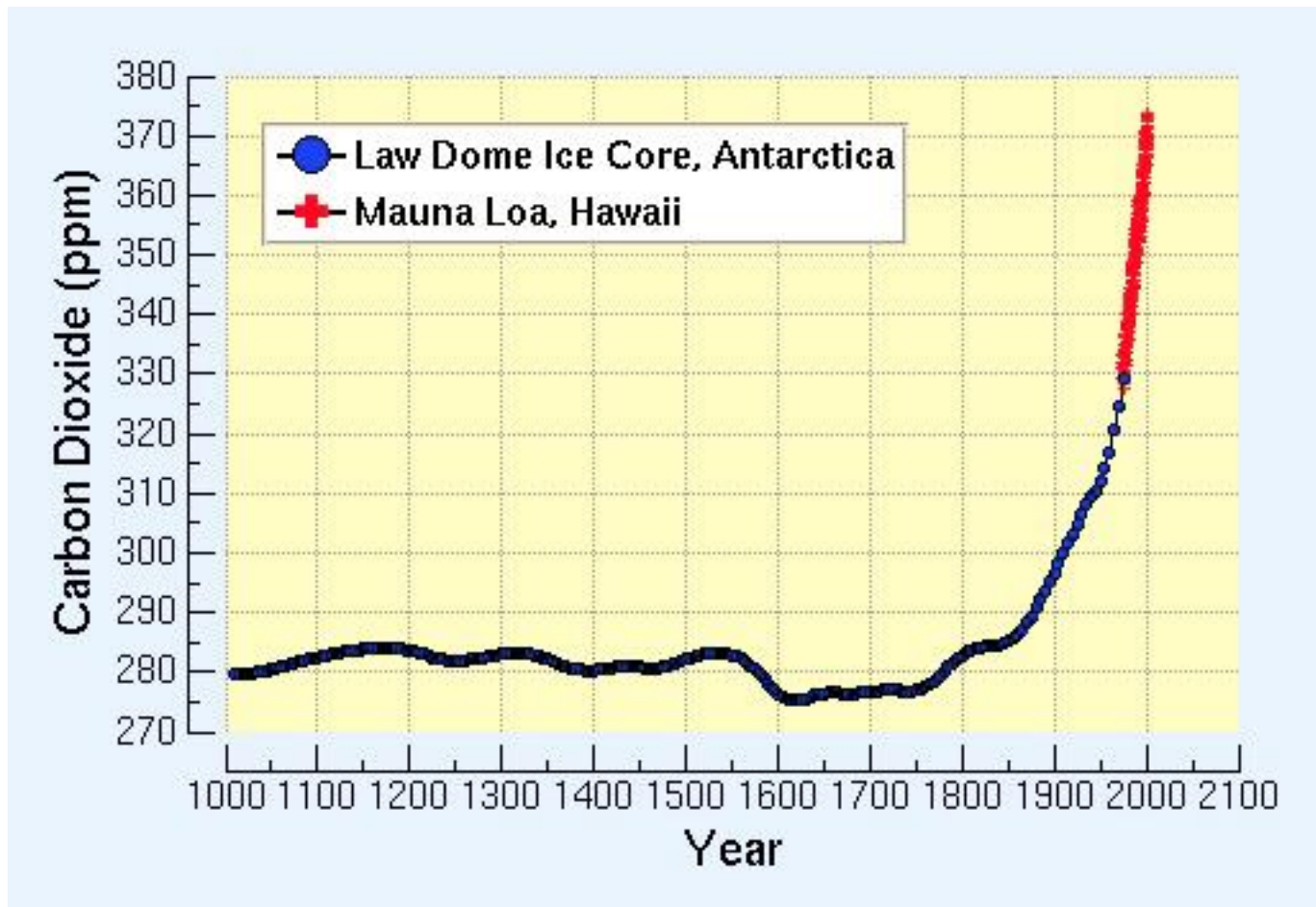
Four Critical Separations

Western democracies rely on four critical separations to try to ensure that power does not become overly concentrated, and to sustain 'checks and balances':

1. Separation of powers (executive, legislative, judicial)
2. Separation of religious institutions from the state
3. Separation of government from the economy (to the extent possible; private property)
4. Separation of government from the media

8. We Are Being Followed

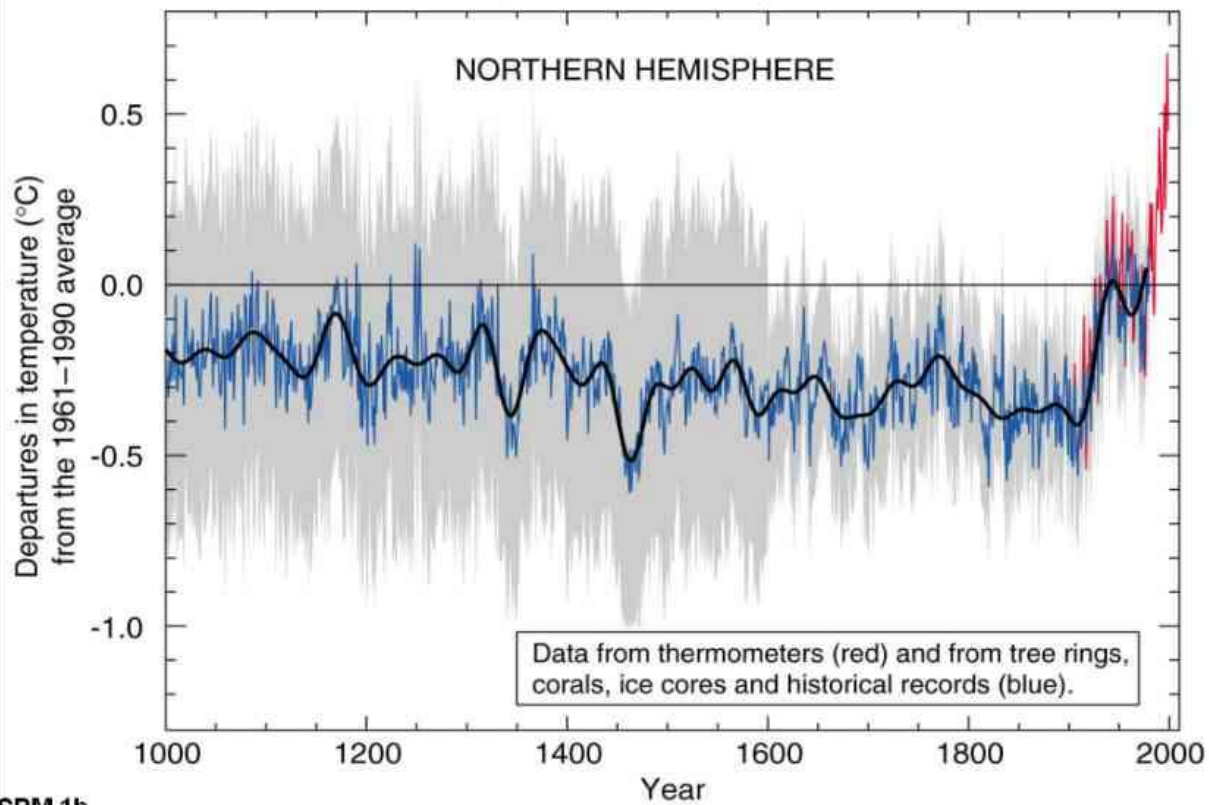
Mother Earth is watching



8. We Are Being Followed

Mother Earth is watching

Variations of the Earth's surface temperature for the past 1,000 years



SPM 1b

9. Necessity is the Mother of Invention

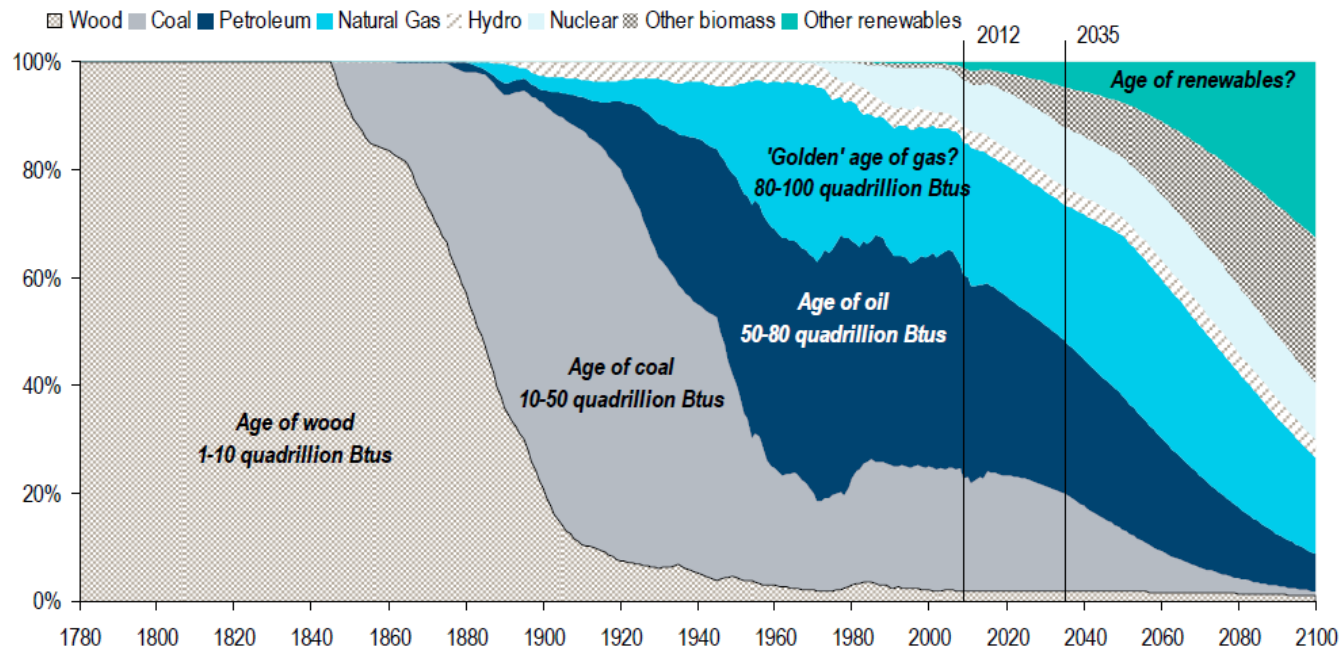
Endogenous technological change

- the need to avoid the Silk Road contributed to the explorations of Columbus, Vasco da Gama, and many others, including those searching for the North West passage (which is now passable due to global warming)
- industrial revolution launched by widespread use of coal and the invention of engines, initially needed to pump water out of coal mines
- the need for motor fuels led to the production of 'synfuels' from coal by the Nazis because they were unable to capture conventional oil supplies (the same process was later used by the apartheid South African Government during oil embargos)
- the Manhattan Project which led to the atom bomb resulted from the need to ensure that the Nazis did not develop it first
- current technologies are insufficient to solve our global warming problems (they are still too expensive) – breakthrough technologies are essential

9. Necessity is the Mother of Invention

Energy Transitions

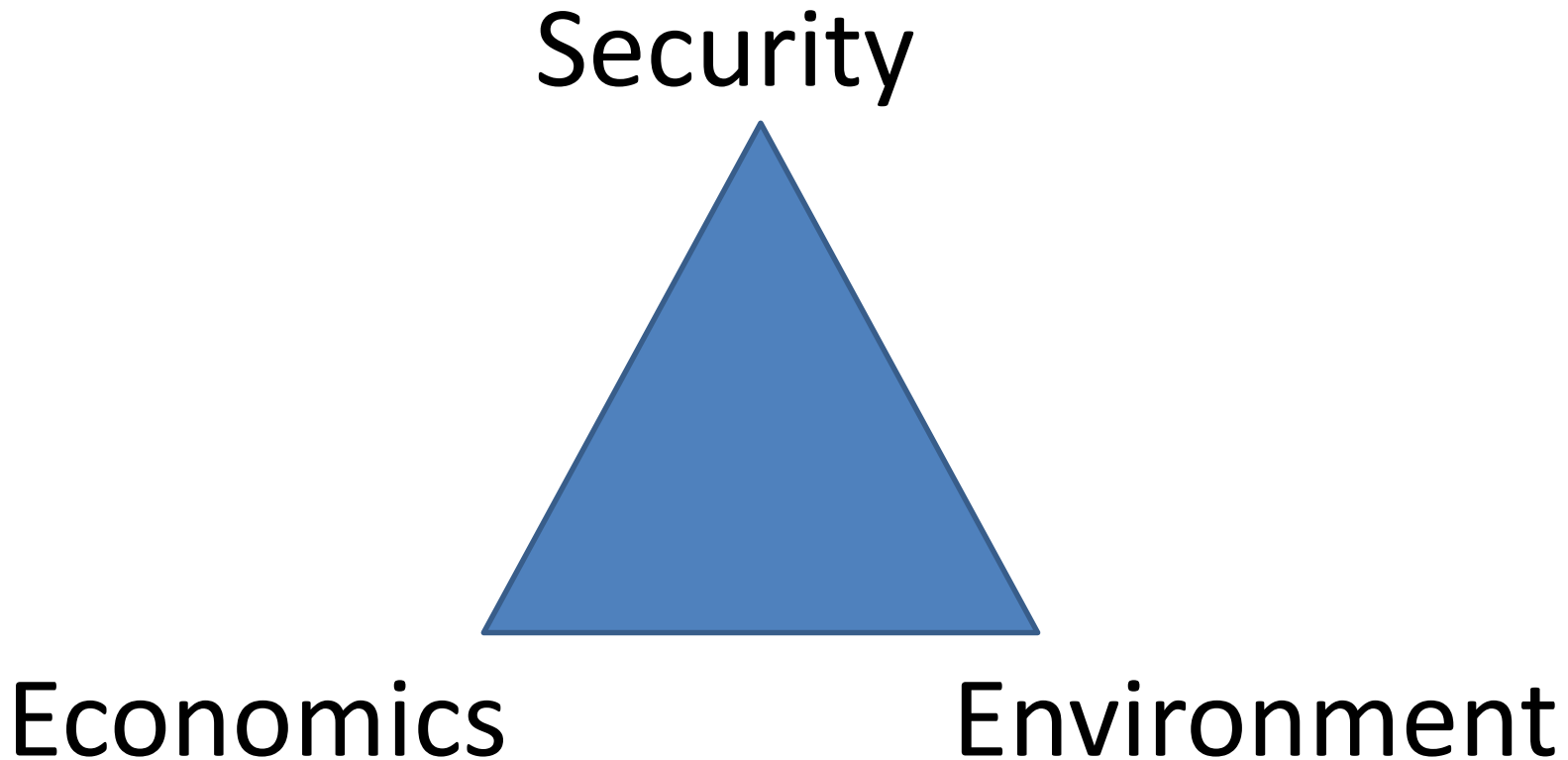
Figure 1. The ages of energy in the US: history suggests a process of substitution



Source: IEA, EIA, Citi Research

10. The Energy Policy Trilemma

How are policy decisions made?



10. The Energy Policy Trilemma

- Fracking and the interplay between the essential energy policy elements.
 - Security – Shale oil and shale gas contributes to making North America energy independent.
 - Economics – Shale resources create jobs, generate exports, so beneficial to the economy.
 - Environment – Continued exploitation of oil, gas (and coal) will continue to increase CO₂ concentrations and contribute to global warming.

10. The Energy Policy Trilemma

What are the 'big challenges' facing the planet?

1. Erosion of liberal democracy – security
2. Climate change – environment
3. Poverty and inequality – economics

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1. Worshippers of the Sun
2. Foiled Again
3. A Most Gregarious Personality
4. Temperature Rising
5. Napoleon's March
6. Geography and History Matter
7. Institutions Matter Even More
8. We Are Being Followed
9. Necessity is the Mother of Invention
10. The Energy Policy Trilemma

11. Scalability

- Why did oil prices drop in 2014, and remained low?
- Are solar, battery storage and micro-grids fundamentally change the regulatory model?

1. **Could the iron age have preceded the bronze age?** No. Iron has a higher melting point than copper and tin (the components of bronze).
2. **What do bicycles have to do with the horrors of the Belgian Congo?** The invention of the bicycle drove the demand for rubber from rubber trees in the Congo.
3. **What does Rembrandt have to do with peat?** Peat was an important source of energy during the Dutch Golden Age.