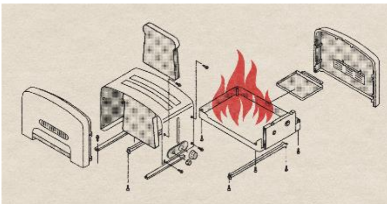
Chapter Six - Which is the Greater Energy Need Thermal or Electrical

Understanding the huge role of natural gas

The fire – which we have used in our homes for over 400,000 years – remains the most versatile and sustainable household technology that humanity has ever known. Fire alone provided what we now get through a combination of modern appliances such as the oven, heating system, lights, hot water boiler, tumble dryer, and television. Unlike these newer technologies, fire had no need for a central infrastructure to make it work, and it could be built locally from readily available materials.



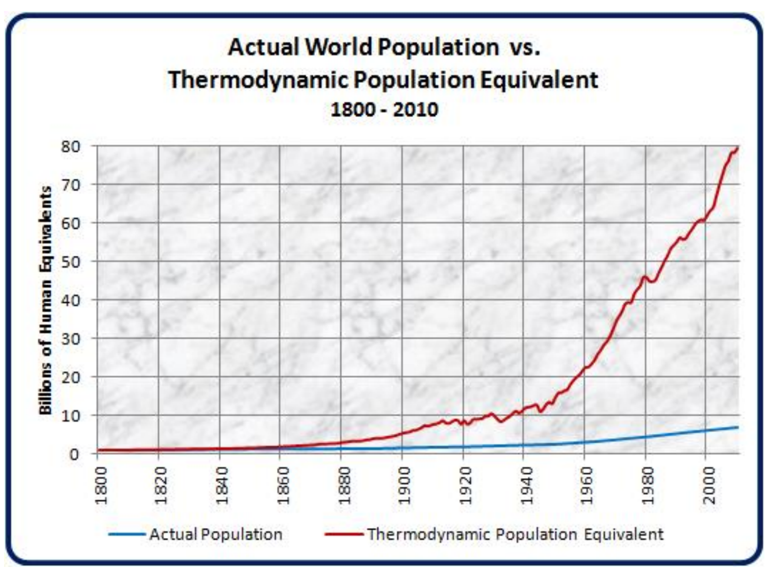
Central infrastructure relied on today is the electrical grid (which more and more relies on natural gas) and natural gas pipelines to our houses.

"Natural Gas: I'm probably more focused on gas than oil. And it's, you know, it's a little bit like real estate. I mean we made a fortune because we bought real estate at a discount to replacement cost. Well we're buying gas in the ground, gas that's been drilled. People have spent $10 million a well, we're buying wells at dramatically less than that. So it's the same kind of creating a competitive advantage by virtue of your entry price" stated Sam Zell, Dec 2015. Read more at http://globaleconomicanalysis.blogspot.com/2015/12/sam-zell-warns-recession-coming.html#deltRemkASMEcxpB.99

Samuel "Sam" Zell is an American business magnate. He is chairman of Equity Group Investments (EGI), the private investment firm he founded in the 1960s. The majority of his investment portfolio ranges across industries such as energy, logistics, communications and transportation, but he is often best known for his pioneering role in creating the modern commercial real estate industry. EGI's holdings also include fixed-income investments in public and private companies.

Zell is also the founder and chairman of Equity International, a private investment firm focused on building real estate-related businesses in international emerging markets. In addition, Zell maintains substantial interests in, and is the Chairman of, a number of public companies listed on the New York Stock Exchange, including: Equity Residential (EQR), the largest apartment real estate investment trust (REIT) in the U.S.; Equity LifeStyle Properties (ELS), a REIT that owns and operates manufactured home and resort communities; Equity Commonwealth (EQC) a leading office REIT; Covanta Holding Corp. (CVA), an international owner/operator of energy-from-waste and power generation facilities; and Anixter (AXE), a leading global provider of communications, security, wire and cable products. Zell understands real estate and energy and I believe he knows a lot about what's coming**,** given his above quote. Timing is always important as is vision, understanding and patience in successful investing. Zell has proven it time and time again since the 1960's. I have not seen an update on how Mr. Zell's portfolio has been performing since he began betting on buying up natural gas resources in 2015 but I would be willing to bet he is still buying but we can see where he expects to reap huge reward over the coming decades. In 2020 Warren Buffet just made his largest single bet ever on natural gas… Hmmm… **As of 2022 is Buffet the philanthropist investing in the so called green new deal… No… see** https://www.zerohedge.com/markets/occidental-soars-after-filing-shows-buffett-seeking-50-stake

Many of the basic functions of civilization rely on chemical or physical transformations driven by heat: smelting, forging, and casting metals, creating glass, refining salt, making soap, burning lime, firing bricks, roofing tiles, clay water pipes, bleaching textiles, baking bread, brewing beer, distilling spirits and driving the advanced Solvay and Haber processes. Transient bursts of fire imprisoned inside the pistons of the internal combustion engine power our cars and trucks, and every time you flick on the light switch at home, you're still most likely using fire that has been trapped in a remote location, its energy extracted, changed in form, and then sent down wires to your electric bulb or what have you. Our modern, technological civilization is just as dependent on the basic application of fire as our ancestors cooking around the hearth in the earliest human settlements. The story of civilization itself has been an epic of the containment and harnessing of fire with ever greater finesse to attain ever higher temperatures: from the cooking campfires to



the pottery kiln, the Bronze Age smelter, the Iron Age furnace, and the blast furnace. In many ways the steam era never really ended. Though we don't use steam engines as prime movers for machinery or vehicles anymore, more than four - fifths of the electricity used around the world is generated using steam: firing a boiler with the heat released by combusting coal or gas, or by the disintegration of unstable heavy atoms in a nuclear fission reactor.

The chart of the thermodynamic (i.e. energy slave) population equivalent and actual human population reveals the staggering size of industrial civilization's reliance on fossil fuels.

Today, the average person on the planet consumes power at the rate of about 2,500 watts (although about 1/3 of the world's population does not have electricity), or put in a different way, uses 600 calories per second. About 85 percent of that comes from burning coal, oil and gas, the rest from nuclear and hydro (wind, solar and biomass are mere asterisks on the chart, as is the food you eat). Since a reasonably fit person on an exercise bicycle can generate about 50 watts, this means it would take 150 people working for you, working eight-hour shifts each, to peddle you to your current lifestyle. (Americans and Canadians would need 660 such workers, French 360 and Nigerians 16) Next time you hear someone lament human dependence on fossil fuels, pause to imagine that for every family of four you see in the street, there would need to be 600 unpaid slaves back home, living in abject poverty: if they had any better lifestyle they would need their own slaves (work now undertaken through motors, appliances and automation is sometimes referred to as fossil fuel energy slaves).

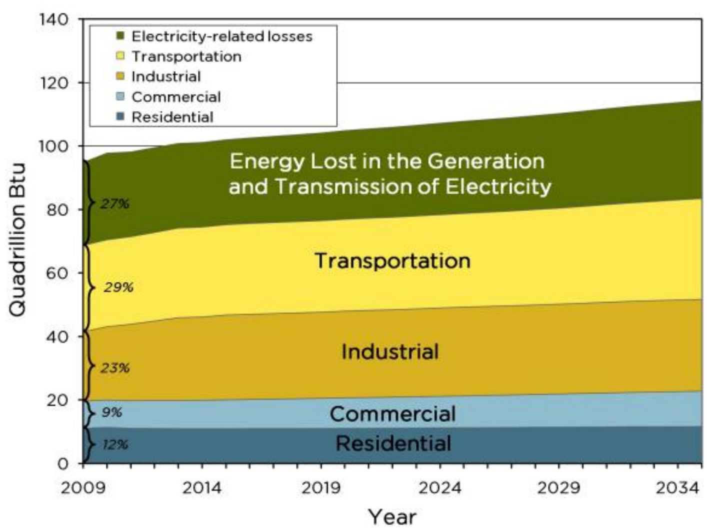


Figure 2. U.S. energy consumption by end-use sector projected through 2035. This is the EIA's reference case projection from its *Annual Energy Outlook 2011*.[12] Roughly 68% of the energy used to generate electricity is unavailable due to generation and transmission losses.

The energy industry is arguably the largest industry in the world. It should be no surprise that also means it is enormously complex. A lot of the how and why it functions as it does is not particularly well understood and that by itself is one of our biggest problems by far! When we think about greening the energy industry or migrating to renewables more thought and progress seem to have been given to electricity than thermal outputs with few even being able to answer the basic and simple question; is that because electricity use is larger than thermal requirements? Of course that answer too is complex, so by way of answering we will break down the largest uses of energy as per the above Energy Information Agency analysis.

The EIA analysis shows is that transportation is the largest use of energy in the world. *"Fossil fuels store an astounding amount of energy. One gallon of gasoline can release 33,700 watt-hours of energy. Let me put that sterile number into perspective. A person working vigorously at a sustainable pace, say, mowing lawns or framing a house, can put out about 250 watts per hour. But look what she could trade for that physical work: If she takes home $20 per hour, one hour of work will buy 5 gallons of gasoline at a price of $4 per gallon. Thus she is trading 250 watts of her energy for 168,500 watts of fuel energy, a phenomenal bargain. Translated into typical work weeks, 1 gallon of gasoline yields the same amount of energy as three months of one person's physical labor. Oil geologist Euan Mearns has calculated that the work available in one barrel of oil, as human labor at $20 per hour, is worth $933,000. Compare that to oil's recent price of between $20 to $100 per barrel. No wonder we live better than kings did before the oil age. Liquid fuel is also energy dense and gets energy to us quickly. To generate the energy in a gallon of gasoline, a standard 120-watt solar electric panel needs to run for about sixty days in average US sunshine (five hours* *per day). In fossil energy we have been given an incredible bargain, even at today's prices"* Toby Hemenway, The Permaculture City: Regenerative Design for Urban, Suburban, and Town Resilience.

But we give far too little thought and actual calculation to what would it truly take to replace oil in our transportation system, rather often deferring to magic wands and pixie dust. For example, the chart below shows that if were to use every available pound of vegetable oil and animal fat for diesel fuel manufacture we would be able to supply 13.5% of diesel transportation needs and we would not touch gasoline use, which is far greater.

Supply VS Demand

Vegetable oil production (billion pounds/yr)		Animal fats (billion pounds/yr)	
Soybean	19.55	Edible tallow	1.753
Peanuts	0.161	Inedible tallow	3.657
Sunflower	0.305	Grease	2.617
Cottonseed	0.99	Yellow grease	1.367
Corn	2.413	Other grease	1.25
Canola	0.626	Lard	0.265
Safflower	0.056	Poultry fat	1.019
Total Vegtable Oil	**23.659**	**Total Animal Fat**	**11.928**
Source: Building A Successful Biodiesel Business, Iowa State University			

	On-Highway Diesel	
	(billion gallons/yr)	(billion pounds/yr)
1996	26.96	191.1
1997	26.61	202.9
1998	30.15	213.8
1999	32.06	227.3
2000	33.13	234.9
2001	33.22	235.5
2002	34.31	243.2
2003	37.1	263
2004	37.13	263.2
Source: www.eia.doe.gov		

- Biomass accounted for 53% of U.S. renewable energy consumption (see https://www.eia.gov/totalenergy/data/monthly/pdf/sec10_3.pdf?src=email), wind energy 18%, solar energy 6%, and geothermal energy 2%.

A quick analysis of transportation use tells us that, in fact, heat driven reciprocating engines and to a lesser degree heat driven turbines (air transport) is what we mostly use for transportation. A move to renewable electricity driven vehicles or even planes largely becomes an effort to hopefully generate electricity from the sun (solar, wind, etc. are all sun derived energy as we have discussed before). If these renewable sources are not enough, then we tend to forgo renewable as we generate heat which generates electricity and then propulsion with energy loss through each phase. Such is the second law of thermodynamics. Even fuel cells participate in this, as hydrogen is most often derived by burning natural gas first. Transportation derived from easily transportable oil and its derivatives such as gasoline or jet fuel is far and away, most often, ultimately heat/thermally driven.

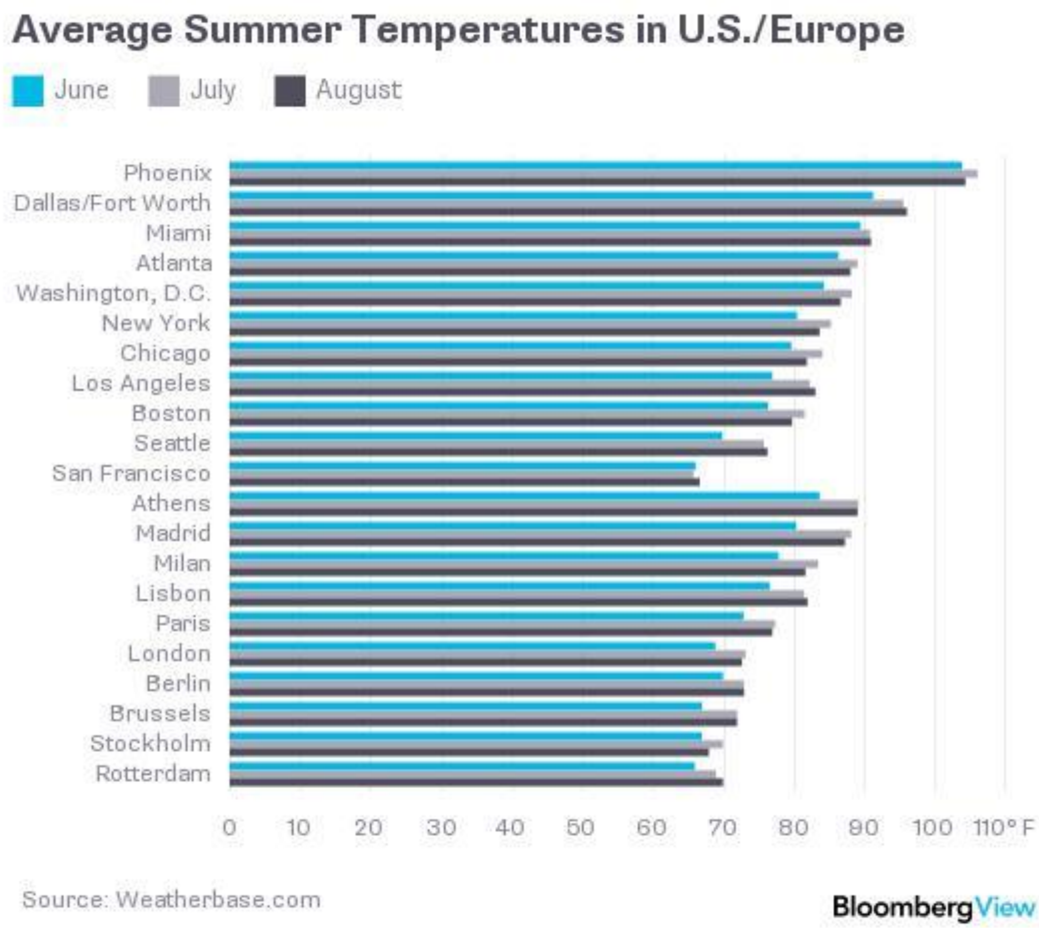
The second largest use of energy in the world is waste heat from central fired fossil fuel and nuclear electricity power generation sites. The world over, such power generation facilities whether coal, oil or natural gas are predominately fossil fuel and heat driven. High quality heat or steam is generated with resulting waste heat (so called low quality less that 80°C heat) generally too distant from where said low quality can be put to use (e.g. space heating homes as it does in Denmark) and therefore it just wastefully heats the atmosphere. This is being changed, to a degree with solar, wind, geothermal and tidal energy, etc. but as we have discussed, energy sourced from the sources with the highest energy density, is of the highest utility and therefore renewables provide a minority of electrical generation, the world over. Even nuclear energy is a heat driven endeavor albeit the fuel source is uranium.

source: Zimmermann, Rehberger, Gößling-Reisemann

When we break down industrial uses of energy, again we find that thermal requirements for making glass, cement, fertilizer, steel, plastics, etc. is larger than pure electricity uses. To green these many and complex processes means that we can only succeed fully if we have discovered and commercialized a green and renewable approach to thermal outputs and associated processes. The cement making process would for example need to be hugely revolutionized. A 100% renewable approach to electricity were it feasible, for industrial processes, would, in fact, have greened well less than half of the industrial complex.

Such facts are too rarely talked about and even less understood. For energy being the fundamental and the ultimate currency of our economy; it is stunning and epically problematic to see such a common low level of energy literacy.

When it comes to commercial and residential use of energy, which is predominately buildings and space temperature comfort requirements, we have to consider geographic location.



Heat waves in Northern Europe cause much the same hysteria that we see in say Washington, when two inches of snow is forecast. Because they have air conditioning, Americans do not have to panic when the mercury rises. Nor do they have incredible fatalities among the old and vulnerable when they happen (see https://usatoday30.usatoday.com/weather/news/2003-09-25-france-heat_x.htm).

In the south of Europe, they do have higher temperatures, of course – though of the biggest cities in each European nation, only Athens and Madrid are consistently as warm as medium-hot American cities like Atlanta and Washington. These warmest European locales are, I must note, places where the city sort of empties out during the summer, and anyone who stays is eager to install air conditioning.

You could argue that if Americans had not migrated amass from the temperate north to the blistering sunbelt, we would need less energy for climate control. You could argue that, but you'd be wrong. Americans still expend much more energy heating their homes than cooling them. That's actually not that surprising. The difference between the average temperature outside and the temperature that is comfortable inside is generally only 10 to 20 degrees in most of America, for most of the summer. On the other hand, in January, for the residents of Rochester, New York you need to get the temperature up from an average low of 18 degrees (-8 Celsius) to at least 60 or 65. That takes a lot of energy.

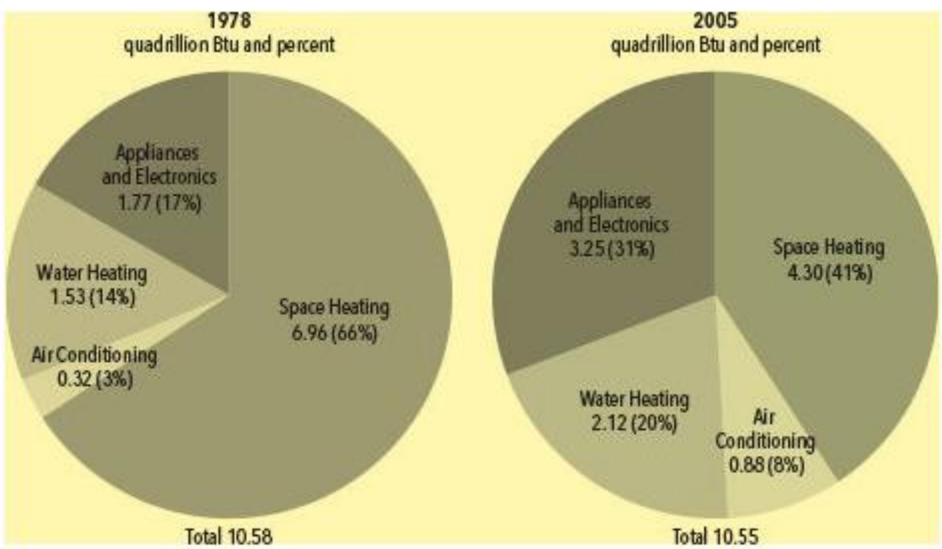
On average, the move from cold areas to warm ones has actually saved energy (see https://slate.com/technology/2012/08/air-conditioning-haters-its-not-as-bad-for-the-environment-as-heating.html), not caused us to use more. So why are we so down on air conditioning, while accepting flagrant heat use as normal? In part, it's because air conditioning still seems optional. Unlike a cold winter with no heat, a hot summer with no cooling won't *definitely* kill you.

"In countless cases, we've made a drastic mismatch between the high quality of a fuel or energy type and the low quality of work done at the consumer end. In many cases all we want is heat, and from a thermodynamics point of view, heat is low-quality, quite disorganized energy compared to the refined, complex structure and processes of gasoline or the electric grid. The

result is needless waste. A classic example of this is electric heating. We go to a lot of work to refine a fossil or nuclear fuel into a pure, highly organized form, then burn it at over 1,000 °F to vaporize steam to spin a turbine to whirl a magnet in an armature to generate electricity. That's a complex process. Electricity is a supremely high-quality type of energy that can power delicate electronics or LED lights and do other tasks that only electricity can do. But instead, these precious amperes travel many miles at about 10% transmission losses until the remaining electrons are finally pumped into a resistant coil of wire to jostle each other until they give off low-quality, low-temperature heat— heat that could have been created by any number of simple fuels or heat sources. That heat is then radiated into the air, probably never to do useful work again" Toby Hemenway, The Permaculture City: Regenerative Design for Urban, Suburban, and Town Resilience.

A perusal of energy data pulled up two notable trends. First, although household size has shrunk since 1940 — back then the average house held 3.7 people, against 2.5 in 2012 — the size of new houses has bloated from 1,100 square feet then to 2,300 today. So each American has triple the room today that her predecessors had in 1940. Although Americans are using less energy for space heating than they were in 1978 as a percentage of expenditure, they are using much more for everything else: hot water, air conditioning, appliances and electronics. In spite of efficiency increases (or perhaps because of them), total energy consumption has not decreased since 1978. Source: US Energy Information Administration, http://www.eia.gov/consumption/residential/reports/2009/electronics.cfm. Can you say Javon's Paradox!

The other trend is that heating and cooling are a much smaller share of our energy use today, but — no surprise here — we're using twice as much electricity for home electronics and appliances. In 1978 we spent 69 percent of home energy use on heating and cooling and 17 percent on powering appliances. In 2009 those numbers were 48 percent and 34 percent, respectively. Because houses are better insulated today and furnaces more efficient, they use less of our total home energy budget than they did, but we've made up for this by doubling the proportion of juice drawn by our plug-in gear. We've gotten more efficient, but we own far more toys. This is living proof of Javon's Paradox or Pareto's law, which says that increases in efficiency won't result in less consumption but in more use of these efficient devices. All we've done is juggle where we use energy, and the result is that total household energy use is about the same as it was in 1978.



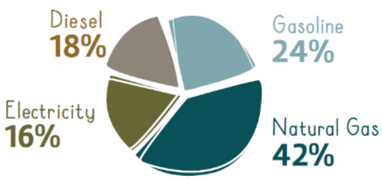
For cooler climates space heating is mostly the predominant requirement and increasingly so, as we add the square footage we have, the farther we move from the equator. The warmer the climate, the more space comfort requirement is air conditioning which is predominantly a process of using heat to generate electricity to run chilling equipment. As per the second law of thermodynamics, the fewer energy dissipating steps (or in other words the closer we can be to the burner tip), the higher the efficiency. Interestingly, with cogeneration and trigeneration, we have energy solutions readily available today and being developed, that bring us much closer to the burner tip, to drive down utility costs, conserve energy overall and thus have a positive influence on climate change. When utilities began to generate revenues by metering kWh's, driving efficiency was no longer their primary concern. While the prognosis was, as it was prior to the 1950's, that electricity would be "too cheap to meter" then electromechanical chilling became the market share leader and other closer to the burner tip technologies where neglected, for decades. And still are! With electricity prices moving up at least at a 4%+ annual clip if not much higher, the world over, and often prodded so, by subsidies to renewables, one would hope to see this reversed but we seem no where near that level of energy literacy or sophistication yet.

8/23 US natural gas spikes 81% in 7 weeks, hits new 14-year high – Wolf Street

High natural gas prices continue to hammer Albertans, especially through increased costs of generating electricity. **The regulated rate for electricity has risen over 150%** <https://www.albertainstitute.ca/r?u=jb-rfDKrlo2XVfYc3aiDs-ZhQs8REth7BuBxGbemzXCldgbQiTf3wRUtd9c40WIYrKsMsixYL2ShmH_hV2bvOexpwuDEVOwXPTVGMjdK80s&e=9928dd24c2788f2b862b86e89a28be37&utm_source=albertainstitute&utm_medium=email&utm_campaign=ai_am_2022_08_01_ab&n=5> in the last 18 months to more than 17 cents per Kilowatt hour for many major power producers. The mandatory phase-out of coal, which used to generate a majority of Alberta's electricity, is definitely having an impact on prices.

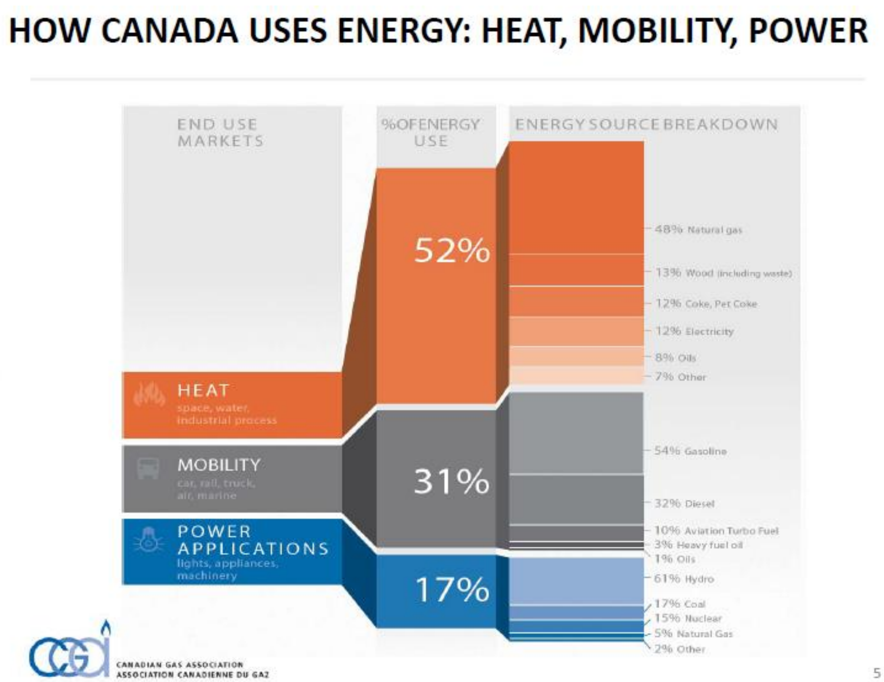
In light of these cost facts, is it fair to say that centralized energy literacy and planning has more than sucked at best and has been nothing short of economic sabotage at worst!

FIGURE 3 Edmonton's Energy Consumption by Energy Type (2012)



This energy was used in four general sectors: residential buildings, commercial buildings, industry and transportation. The transportation sector was the biggest energy user (41.8% of all energy used in Edmonton) followed by large/commercial buildings (22.5%), residential buildings (19.4%), and industrial buildings and processes (16.2%) (Figure 4).

FIGURE 4 Edmonton's Energy Consumption by Category (2012)



Overall electricity is about 25% of the energy requirement. When we note that renewables (hydro, biomass, solar and wind combined) and nuclear worldwide are less than 20% of electricity and energy supply, **one way or another about 80% of our energy needs are in fact, thermal needs**. Our acronym for this is Short Heat Is Trouble!

About 60% of Ontario's natural gas consumption is used to heat homes during the winter months

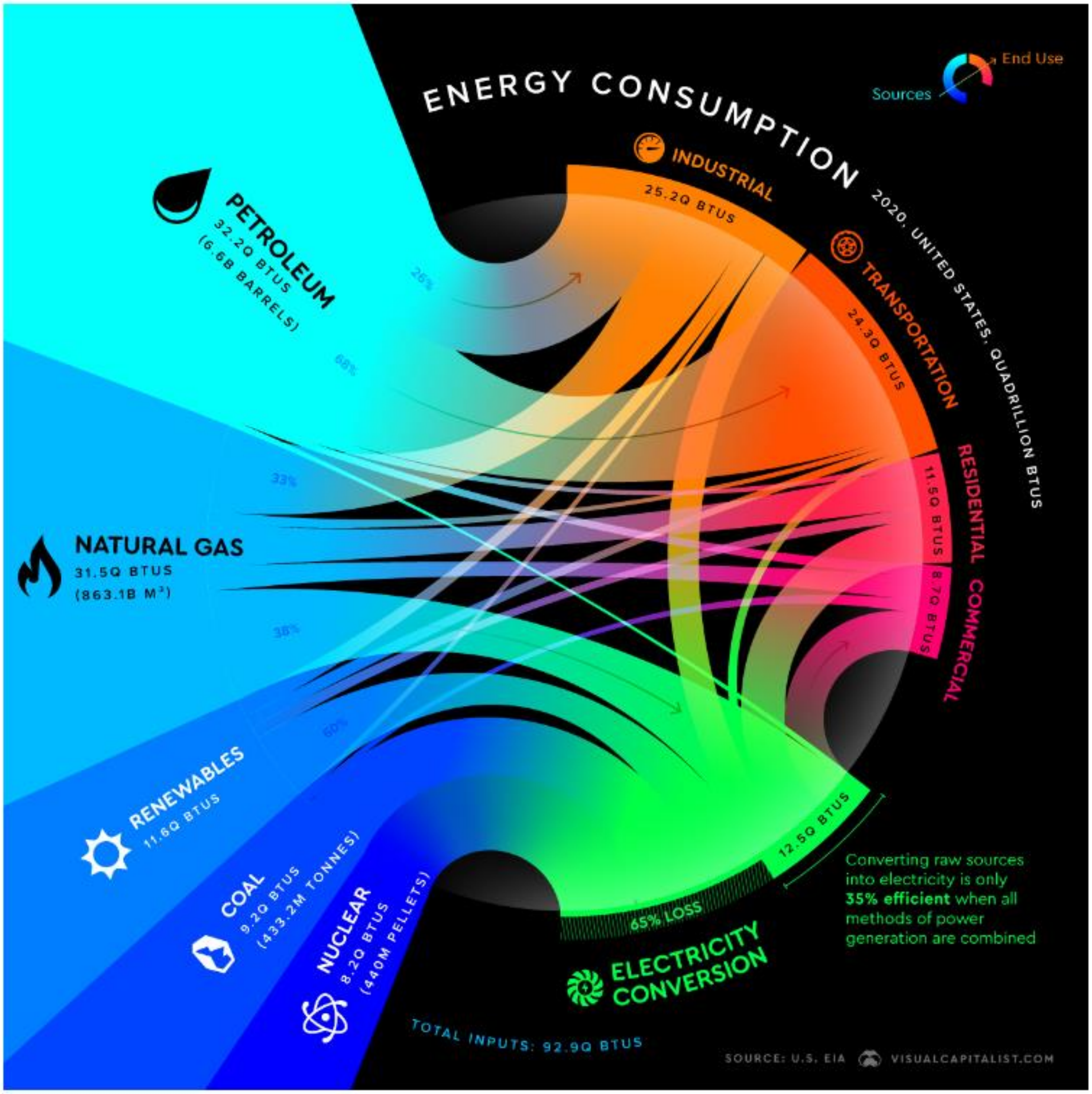
When we delve into how important natural gas has become to thermal output, as we will explore below and with an increased understanding of the natural gas supply chain, we believe readers will agree, it is not misplaced to say we face deep S.H.I.T. without plentiful ongoing affordable supplies of natural gas. But as per our ongoing thesis, if we understand the reality and the why's, we are not lacking for proactive and practical means to improve matters intelligently at least. In other words we can avoid further, oncoming deep S.H.I.T. with knowledgeable proactivity or we can ignore the problem, pretend it doesn't exist

Renewable Alternatives

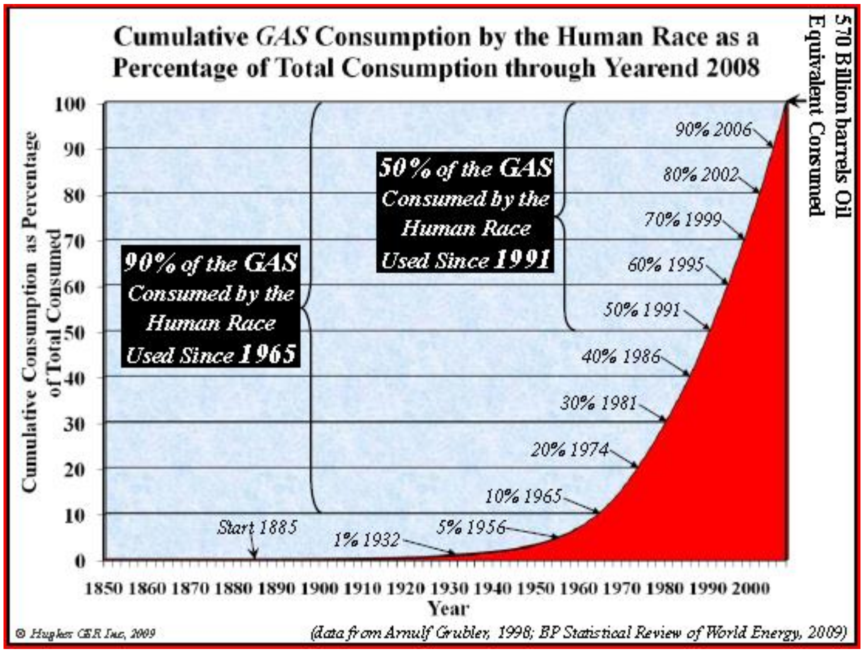
Biofuel Alternatives	Electrical Alternatives	Heat Alternatives	Natural Gas Alternatives
Ethanol:	Biomass (wood waste, peat, other)	Biomass (wood waste, peat, other)	Biogas
Cellulosic	Concentrated Solar Power	Concentrated Solar Power	
Corn (Maize)	Fuel Cells	Geothermal	
Sugar Beet	Geothermal	Thermal Solar	
Sugar Cane	Hydroelectric		
Wheat	Ocean Thermal Energy Conversion		
Other crop-based Ethanol	Ocean Wave Energy		
	Offshore Wind Turbines		
Biodiesel:	Onshore Wind Turbines		
Algae	Photovoltaic Solar		
Canola	Tidal Electrical Power		
Flax seed	Thermal Solar		
Jatropha			
Palm Oil			
Soya			
Sunflower			
Tallow (Animal Fat)			
Other crop-based Biodiesel			

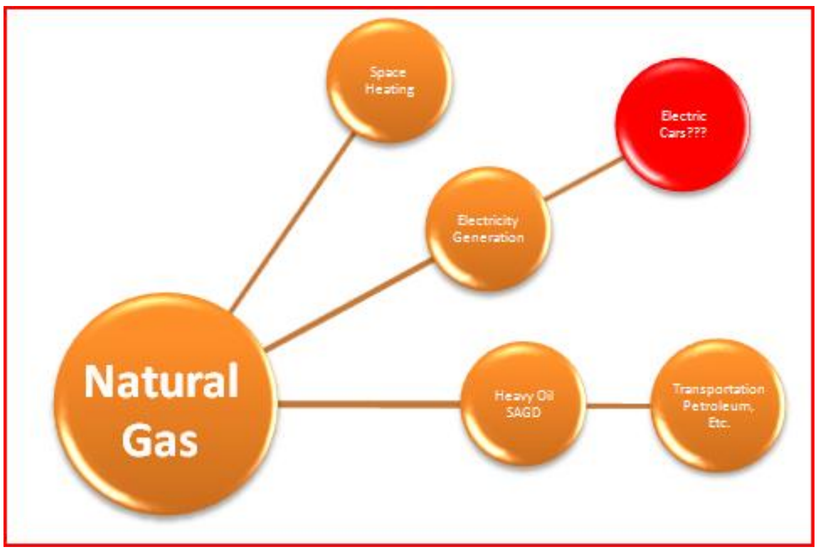
Figure 4. Renewable Alternatives
Sources: EIA, Natural Resources Canada, AltaCorp Capital Inc.

and hope for a continuation of our current anomalous life style (which has existed only about the past 150 years, of all of history) which can be described as a bug hoping the speeding, oncoming windshield offers a place to rest. Not a great way to fly.

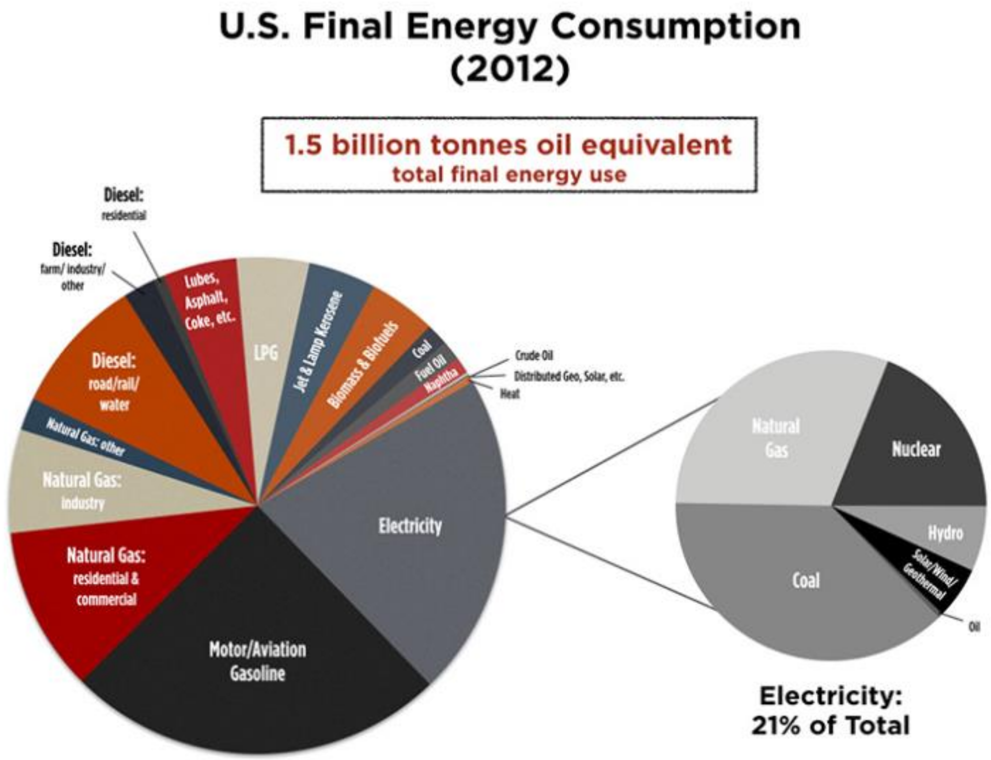


ENERGY CONSUMPTION
2020, UNITED STATES, QUADRILLION BTUS
Sources
End Use
PETROLEUM
32.2Q BTUS
(6.6B BARRELS)
NATURAL GAS
31.5Q BTUS
(863.1B M³)
RENEWABLES
11.6Q BTUS
COAL
9.2Q BTUS
(433.2M TONNES)
NUCLEAR
8.2Q BTUS
(440M PELLETS)
INDUSTRIAL
25.2Q BTUS
TRANSPORTATION
24.3Q BTUS
RESIDENTIAL
11.5Q BTUS
COMMERCIAL
8.7Q BTUS
12.5Q BTUS
65% LOSS
ELECTRICITY CONVERSION
Converting raw sources into electricity is only 35% efficient when all methods of power generation are combined
TOTAL INPUTS: 92.9Q BTUS
SOURCE: U.S. EIA
VISUALCAPITALIST.COM



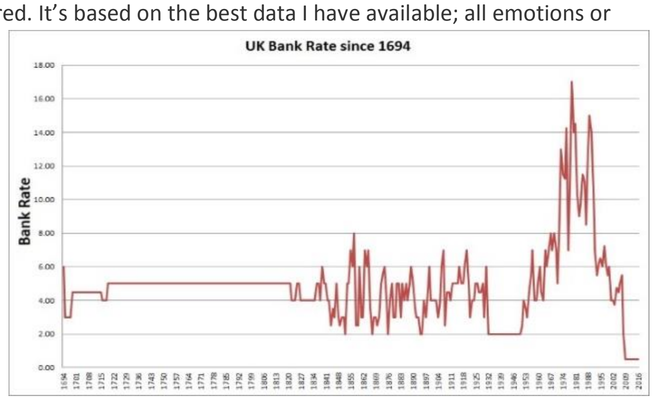


When wood was cheap and plentiful, it overcame solar as our primary energy source. We didn't stop using wood, but when we discovered how to effectively use coal and the dawn of the industrial revolution was upon us, we used coal and before too long coal had to be dug from deeper sources and be shipped longer distances. Massive coal use, meant cities like London were not enamoured by all the ripple effects on air and water quality (just like what China is experiencing today (see http://news.yahoo.com/beijing-factories-shut-amid-smog-nightmare-094309888.html#) Oil was then harnessed, taking us from the late 1800's on and then we also found we could harness and add natural gas to the mix. Firewood has approximately 15 million BTU's per tonne while natural gas has 45 million BTU's per tonne. Many do not appreciate how recent and important fossil fuel derived natural gas use is to the energy mix. Most do not realize or appreciate that 90% of the natural gas used by humans, has been used within their lifetime – specifically since 1991! Even young one's recognize that as 'recent'!



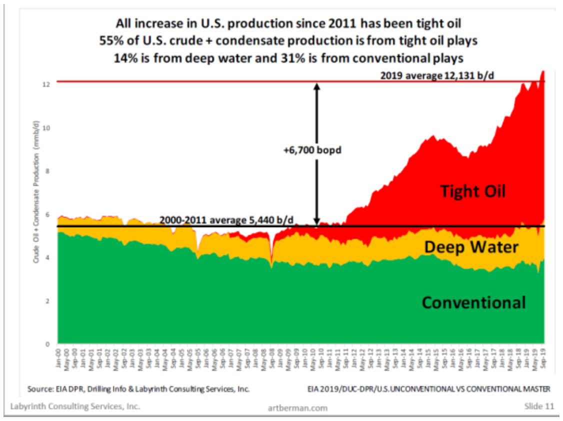
sources: IEA Energy Balances; U.S. EIA

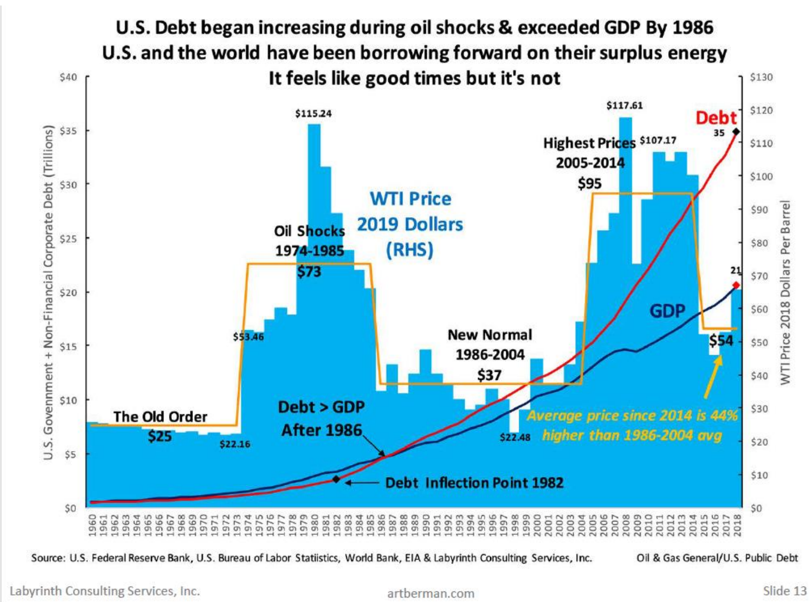
If we fully appreciate the importance of thermal output in our energy mix in the economy and natural gas' essential role of late, in meeting that need, then we'd hope economists, opinion leaders, energy experts and politicians would have well studied the matter and have a strong understanding of the dynamics at play, including supply, demand and associated price. Right? Having studied the area rigorously and in depth for decades, my answer would be an emphatic NO – leaders have too seldom studied the matter, let alone understand it. Further, those few, with such energy literacy and understanding are loathe to talk about it, in my view, because of the difficult changes that solutions might demand and for having watched those with the most understanding of the area, receive the brutal treatment they have endured for sharing their insight. These would include the likes of Malthus, the Club of Rome, Hubbard King, Jeff Rubins and Richard Heinberg. We have discussed before, Malthus, the Club of Rome, Hubbard King, Jeff Rubins or Richard Heinberg, making forecasts, and despite the massive complexity of global energy supply and demand, are horribly ridiculed if they have not pegged a year correctly and all associated prognostications, including commodity prices. It seems great delight is had in taking them out to the proverbial wood shed and declaring everything they are claiming and predicting wrong and all their credibility lost if their predictions have been out in any way. I think this is a direct response to, as Friedrich Nietzsche described *"Sometimes people don't want to hear the truth because they don't want their illusions destroyed."* Perhaps it feels better, at least in the moment, to discredit and contemn the source then to be inconvenienced. I'll risk joining the ranks of Malthus, the Club of Rome, Hubbard King, Jeff Rubins or Richard Heinberg in sharing theirs and others insights below. I would be honored. It's based on the best data I have available; all emotions or wished for futures, aside.

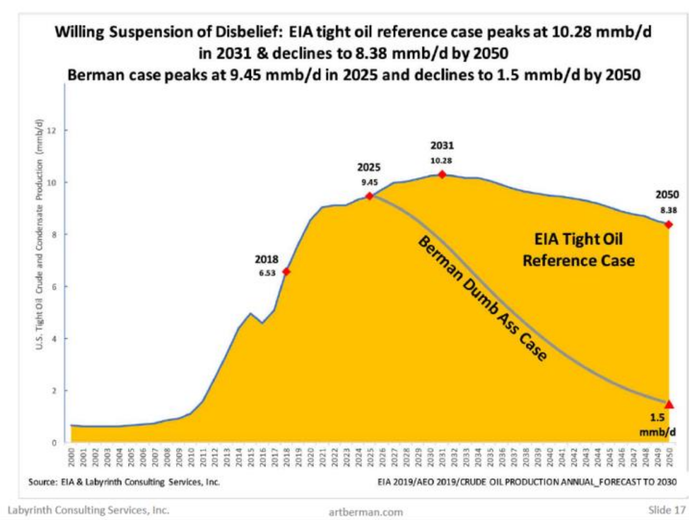


When Richard Heinberg wrote his important book High Noon for Natural Gas, I do not recall him speaking much about shale gas. It's not that shale gas wasn't well known – find a geologist that wasn't well aware of its presence going back to early history in oil and gas exploration. What wasn't appreciated though, was not only the technologies that brought about the great shale gas reprieve but, hugely anomalous and unprecedented in human history - low interest rates, that made the mass onslaught of supply available in the early 2000's and continued until about 2022.

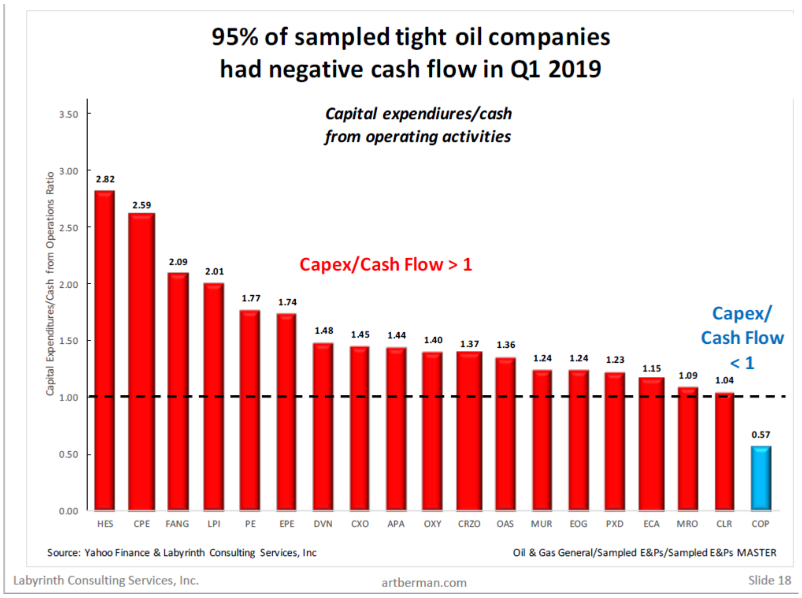
I could devote a lot of space to this but choose instead to mostly to focus on where to from here, given the facts, such as they are. The slides below from Labyrinth Consulting do a great job in summarizing matters.







When it takes a barrel of oil to get a barrel of oil out of the ground, refined and transported to market, the oil era will be largely over, no matter what its monetary price happens to be. As noted below, the global average is currently about 19:1 with oil sands oil at about 3:1. We think it is wise to know the real numbers now and to leverage strategies to prioritize accordingly. We fully acknowledge someone might invent cold fusion in a coffee cup and then the game changes entirely. Perhaps at the same time they might finally invent the perpetual motion machine too, but until it is proven and commercialized, should our strategy really be wishing upon that star and counting on it to come true, any minute now?



ENERGY UNITS EXPLAINED

Here are the commonly used units of measurement of the various forms of energy (electricity, gasoline, natural gas, diesel fuel, home heating oil, etc.).

1 gigajoule (GJ) of natural gas is equal to...				
25.87 m^3 (cubic metres)	913.99 ft^3 (cubic feet)	277.78 kWh (kilowatt hours)	29.787 litres of gasoline	26.116 litres of diesel/home heating oil

$10 per GJ of natural gas is equal to...				
0.3866 dollars per m^3	0.0109 dollars per ft^3	0.0360 dollars per kWh	0.3357 dollars per litre of gasoline	0.3829 dollars per litre of diesel/home heating oil

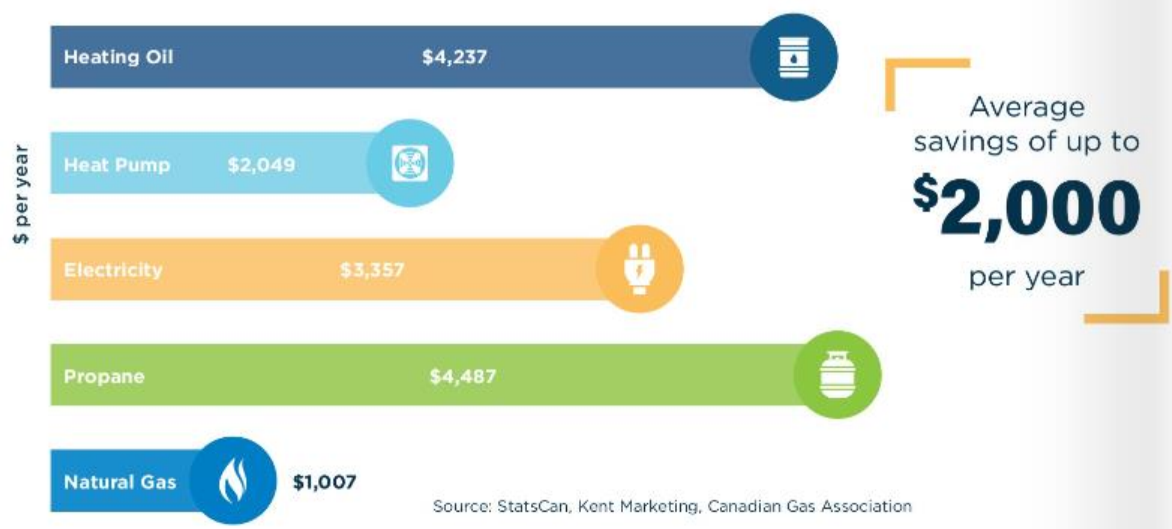
NOTE:

If you paid $10 for a gigajoule of natural gas, this would be equivalent to paying just 3.6 cents per kilowatt hour for that energy as electricity or 33 cents per litre for that amount of energy as gasoline. It is worth noting that the average natural gas delivered cost in 2018 was $7.91/GJ.

ABUNDANT SAVINGS

Households that use natural gas for space and water heating save $1,000 to $3,000 per year compared to homes using propane, electricity, and heating oil for the same applications.

Residential Space and Water Heating Costs - Canada 2018

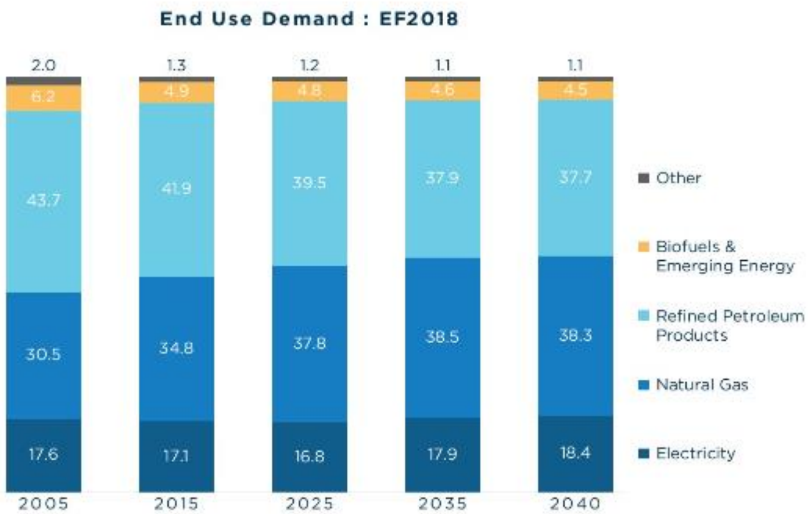


Source: StatsCan, Kent Marketing, Canadian Gas Association

NATURAL GAS

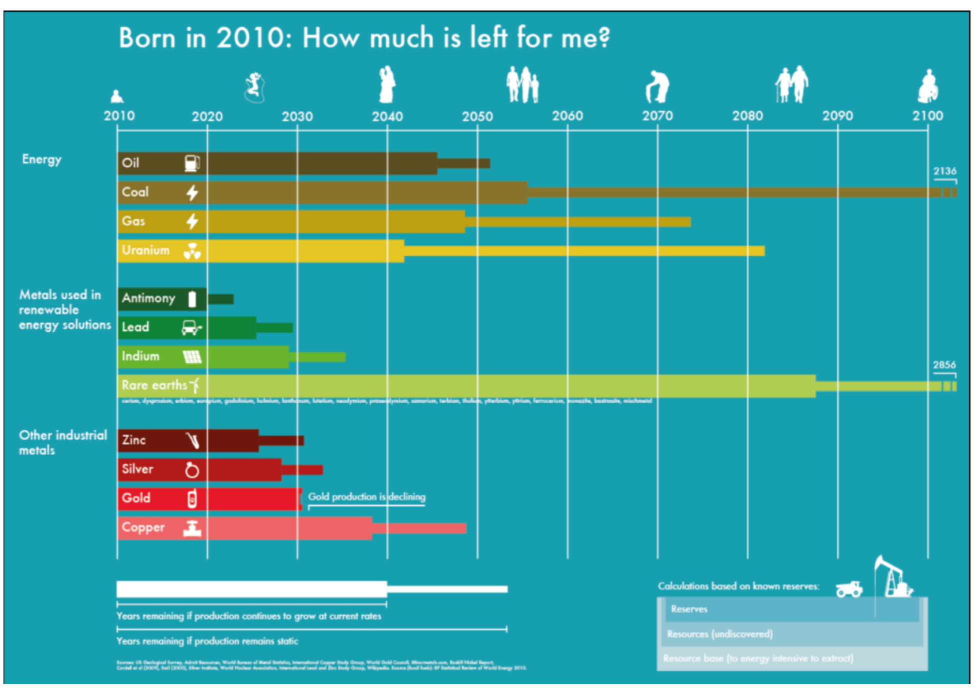
WILL BECOME CANADA'S MOST RELIED UPON ENERGY FORM BY 2035

The Canadian Energy Regulator forecasts natural gas will grow from 35 per cent of end-use in 2019 to 38 per cent by 2035. Natural gas will by this time overtake crude oil/ refined petroleum products for the first time in Canadian history.

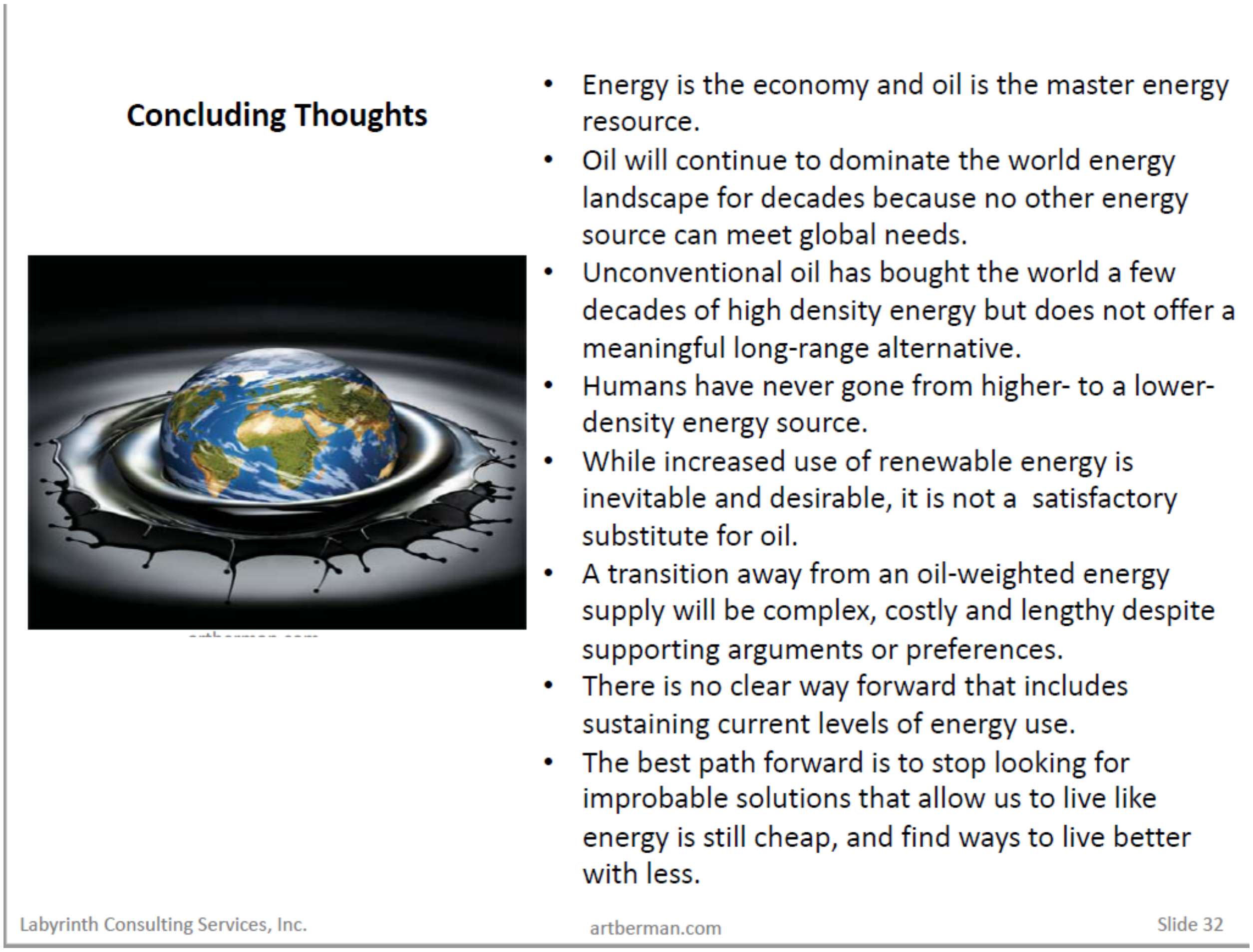


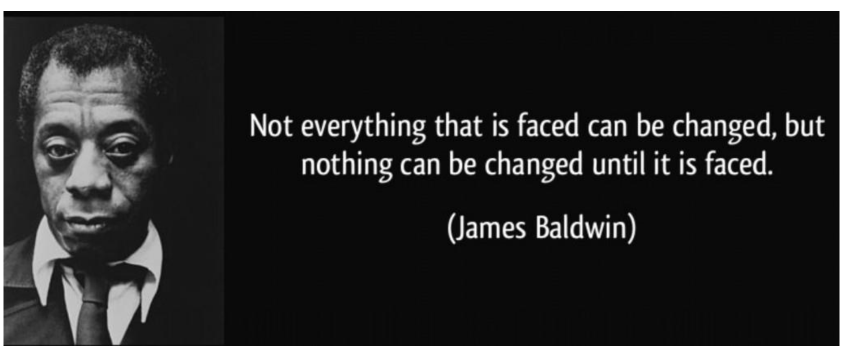
Source: CER Energy Futures Outlook 2018

38%
end-used demand by 2035



Source: https://www.zerohedge.com/markets/were-living-borrowed-time





Winston Churchill "A pessimist sees the difficulty in every opportunity; an optimist sees the opportunity in every difficulty."

How can I prepare for or even shape the dramatic developments in the global energy system that will emerge in the coming years? This question should be on the mind of every responsible leader in government, business and civil society. It should be a concern of every citizen.

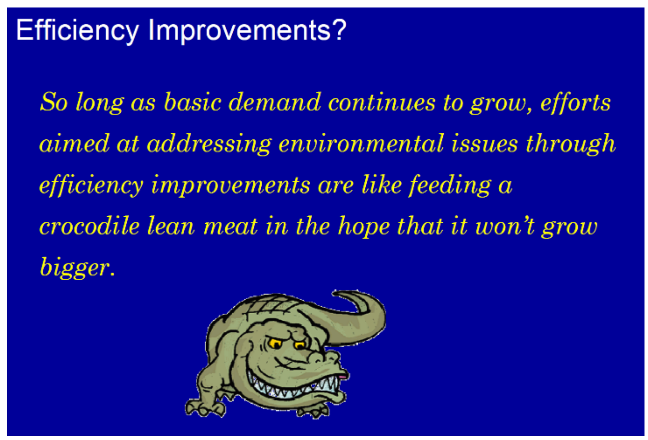
Jeroen van der Veer, former Chief Executive, Royal Dutch Shell plc

The below chart is current natural gas production, less current natural gas use and the balance that results, if current requested LNG export materializes in North America:

Global Natural Gas						
Average global supply and use of natural gas	118	TCF/Yr.			323.9BCF/d	
Global natural gas use in nitrogen fertilizer production	5.9	TCF/Yr.	5%	in 2002		
	7.375	TCF/Yr.	6.25%	with 25% increase since 2008 and increasing exponentially by 1.8% annually		
Canadian Natural Gas						
Canada natural gas production	5.11	TCF/Yr.	4.33%	of global supply	14BCF/d	
Natural gas export to the U.S.	1.825	TCF/Yr.	35.71%		5BCF/d	
Alberta heavy oil	0.7665	TCF/Yr.	15.00%	Cdn. Production	2.1BCF/d	1000 cubif ft for every barrel of bitumen according to the Petroleum Technology Alliance of Canada
Alberta uses for space heating, DHW, etc.	0.52045	TCF/Yr.	10.18%		1.426BCF/d	
Alberta natural gas electricity generation uses	0.27156	TCF/Yr.	5.31%		.774BCF/d for fifty one natural gas power plants and growing as coal is phased out	
Balance used by remainder of Cdn.'s before LNG export	1.72649	TCF/Yr.				
Earmarked for LNG export	1.46	TCF/Yr.	28.57%		4BCF/d plus	
	-1.55851	TCF/Yr.				
U.S. Natural Gas						
U.S. natural gas production	23.7	TCF/Yr.	20.08%	of global supply	65-75BCF/d	
U.S. storage capacity	4	TCF	Equals 55 days of use			
Overall U.S. natural gas demand	24.795	TCF/Yr.			50-115BCF/d	
U.S. Electricity generation	7.3	TCF/Yr.	30.80%		15-35BCF/d	
U.S. natural gas use for nitrogen fertilizer production	0.3555	TCF/Yr.	1.50%	as at 2002		
Natural gas export to Mexico	0.73	TCF/Yr.	3.08%			
Earmarked for LNG export	10.95	TCF/Yr.	43%		30BCF/d	
	-7.6555	TCF/Yr.				

Is it better to drive looking in the rear view mirror or out the front windshield?! For natural gas and therefore electricity and food production, this is an attempt to look out the front windshield now.

Every day, worldwide, the world uses 323.9 BCF of natural gas or 118 TCF/yr. The US has about 4000 BCF of natural gas storage which equals about 55 days of heating season supply according to the US Energy Information Admin.

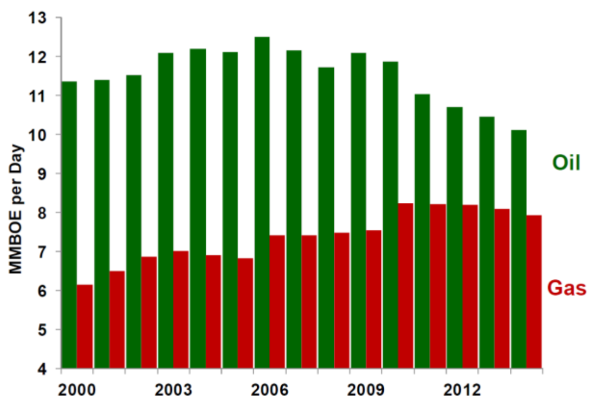


The International Energy Agency pointed out in 2014 that about 50% of the worlds and the United States remaining natural gas reserves are unconventional (Read expensive, with breakeven at about $8+/GJ, as well as expensive in terms of water consumption and environmental impact).

Several geographies that used to be heating oil territories have converted significantly to being natural gas territories such as Boston. This is quite recent and not inconsequential in the consumption numbers. Boston is very telling in another way, and that is because Boston has ample natural gas pipeline and storage capacity for all but 2-3 weeks per year. Boston natural gas prices mirror the remainder of North America's prices for mostly all but those 1-3 weeks per year, but for not having enough storage or pipeline capacity, has meant for about one to three weeks recent winters, Boston has registered the highest natural gas prices on the planet – they are hard to believe and eye popping prices to say the least…how does $32 (winter 2013), $100.25 (winter 2014) and $23/MM BTU (winter 2015) or GJ highs grab you, in each of those successive winters? Seems like a live market test for what market price will be borne, if there is little choice.

Figure 2: Seven Supermajors'* Worldwide Production

Annual; 2000 to 2014e



Source: Company Reports, ARC Financial Research

** BP, Shell, Statoil, TOTAL, Chevron, ExxonMobil, ConocoPhillips*

Note how oil production has been declining for the seven super majors despite shale oil production. Note how important natural gas and therefore shale gas production has been to their overall production especially in light of recent SEC rule changes that allowed oil and gas companies to state production in Barrels of Oil Equivalent (BOE). Lots of people are not aware of these rule changes or their significance (see http://www.bloomberg.com/news/articles/2015-12-10/billions-of-barrels-of-oil-vanish-in-a-puff-of-accounting-smoke)

In a short time we have already seen 17% of American natural gas exported as LNG. From solely a Canadian perspective, I harbor deep concerns about the feasibility and wisdom of massive LNG export. Some important facts about LNG:

- *In order for natural gas to be turned into a liquid (a.k.a. liquid natural gas or LNG), it has to be compressed and refrigerated all the way down to an astonishing -260 degrees Fahrenheit. If you have a refrigerator, you already know that it takes energy to cool something down. And the deeper the cooling, the higher the energy required.*
- *In order to export LNG, it takes energy to simply turn that energy into a liquid. How much? Roughly 25%. That's right; a quarter of the embedded energy in the natural gas is lost before it even makes its way to a customer.*
- *But I heard we have at least 100 years of supply in North America. We might not be able to extract all of the possible and speculative resources that are part of the 100-year calculation. If it turns out that we're only going to be able to extract, say, 75% of everything we think is there, the rest simply won't be economically extractable. If we combine this 75% figure with a yearly increase in consumption of 4%/yr., then we discover there's just 25 years of natural gas left. That's just math. While 25 years is at the extreme end of the dismal view according to some, it does help to bracket the "100 years" claim.*
- *So let's say total gas left is somewhere between the promoted 100 years or less – let's assume a mean value of around 50 years – and this is before we entertain any thoughts of exporting LNG. Any exports will only eat into these figures, possibly quite dramatically.*
- *If we add up all of the proposed projects, including an equal number not on the above list, we discover that their collective export capacity is just a hair under 30 billion cubic feet per day, or a whopping 43% of current U.S. production.*

It would take years to permit and build, of course. Further there are additional reserves coming on stream, whether it is natural gas being sought in the Arctic, shale gas in China or Europe (http://grist.org/news/gas-drilling-is-causing-earthquakes-in-europe-too/) or optimism about one day tapping frozen methane on the bottom of our ocean floors. We will not have burned the last of available supply in 19 years, but we can ascertain, all that is left is going to sell for world prices and we would hazard to surmise that will not be less than Europe's current consistent and likely beyond Japan's consistent price. The question also becomes, under what circumstances and how often, will we toy with Boston's peak prices? Such prices are facts of historical record, not some fear mongering.

The natural gas price question is particularly important when we contemplate natural gas' master currency role in worldwide food production due to how the world's nitrogen fertilizer production and in turn food production requires natural gas for its productivity.

"If Canadian oil-sand production ever increased from its present level of approximately 1.2 million barrels per day to the 4 million per day that the oil industry forecasts, Canada would have to cannibalize its natural gas exports to the United States to do it ... Long before that happens, the attendant loss of natural gas supply to the United States may send North American natural gas prices soaring so high that the underlying economics of oil-sand production make even less sense ... Natural gas trades at an enormous discount to oil. But as we saw only a few years ago when stormy weather knocked out Gulf of Mexico gas production, that ratio can change in a hurry. For a period of almost a year, natural gas prices traded at energy parity premium to oil as the hit to the Gulf of Mexico's gas production was much greater than even it's hammering of oil production." Jeff Rubin in his book Why Your World Is About To Get A Whole Lot Smaller. Rubin was treated harshly for such comments a few short years ago AND he was exactly right according to current prices!

The conclusion is clear, natural gases contribution to thermal and electrical requirements and thus overall energy pricing is nothing short of epic! As I have been saying for over a decade, understanding the challenge and understanding what proactivity and conservation is required, are key intelligent responses, especially if we understand how epically important thermal output is to drive our current standards of living. Putting ones head in the sand, celebrating missed dates or price signals by the forecasters, central planners etc. are not likely to be looked upon favorably by anyone, in the not distant future (say now)!