The Energy Picture Infographic

An Update

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"The pandemic represents a rare but narrow window of opportunity to reflect, reimagine, and reset our world."
Klaus Schwab
WORLD ECONOMIC FORUM


STEP ONE: DIG AND POUR A BASEMENT.
Liberals
DEBT
BUILD BACK BETTER

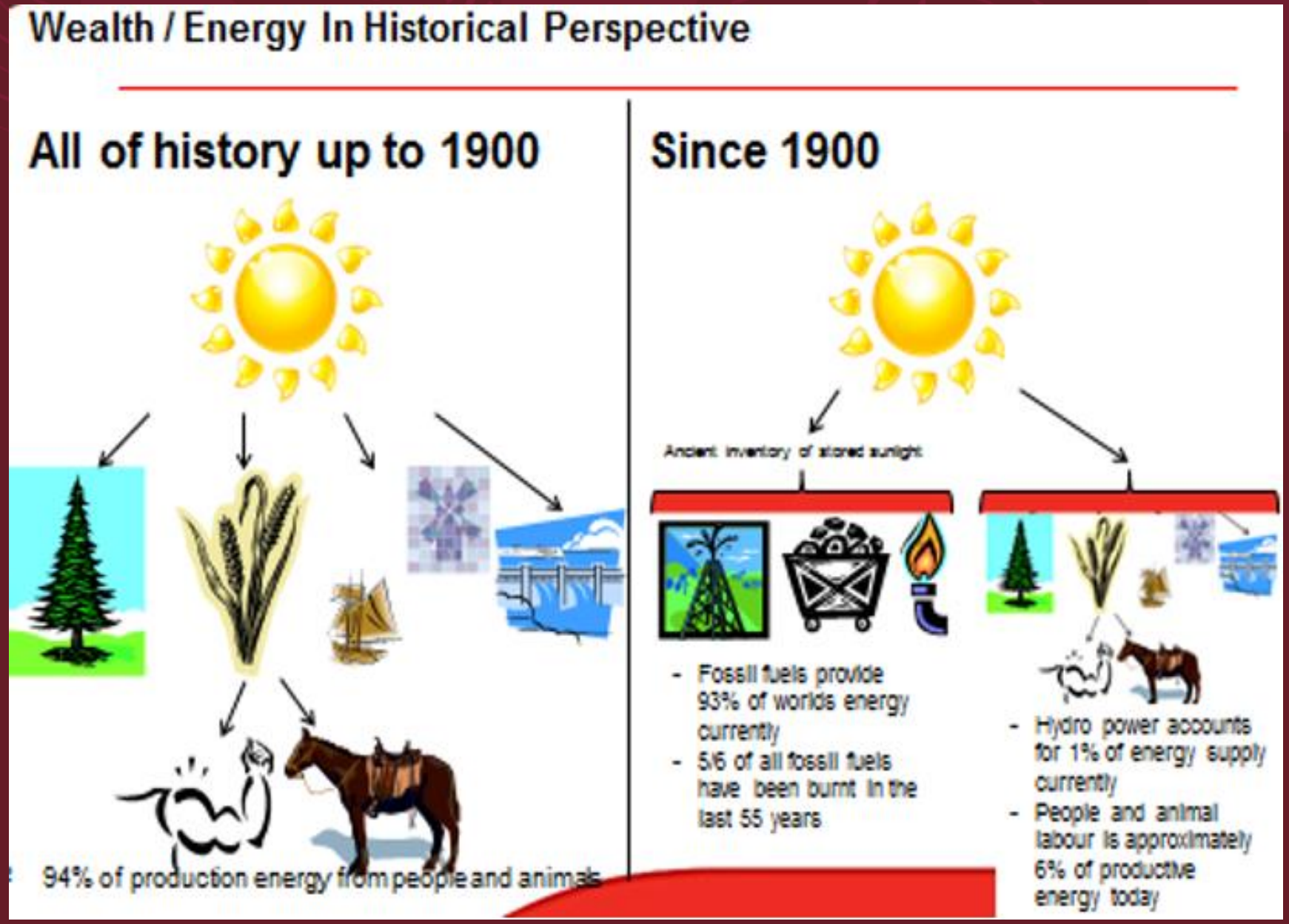

BUILD BACK BETTER
15 July, 15:30-17:00 CEST
Canada
OECD
TACKLING CORONAVIRUS (COVID-19)
CONTRIBUTING TO A GLOBAL EFFORT
PRIME MINISTER IMRAN KHAN
will speak at a High-Level Side Event
OECD Policy Responses to Coronavirus (COVID-19)

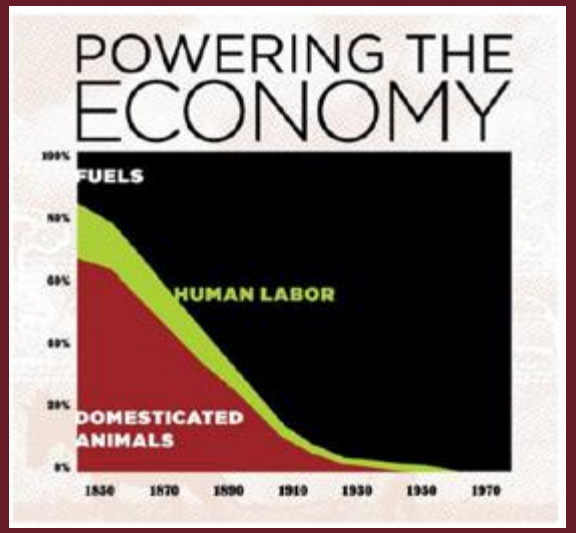
NET ZERO IN ALBERTA

All-Electric approach

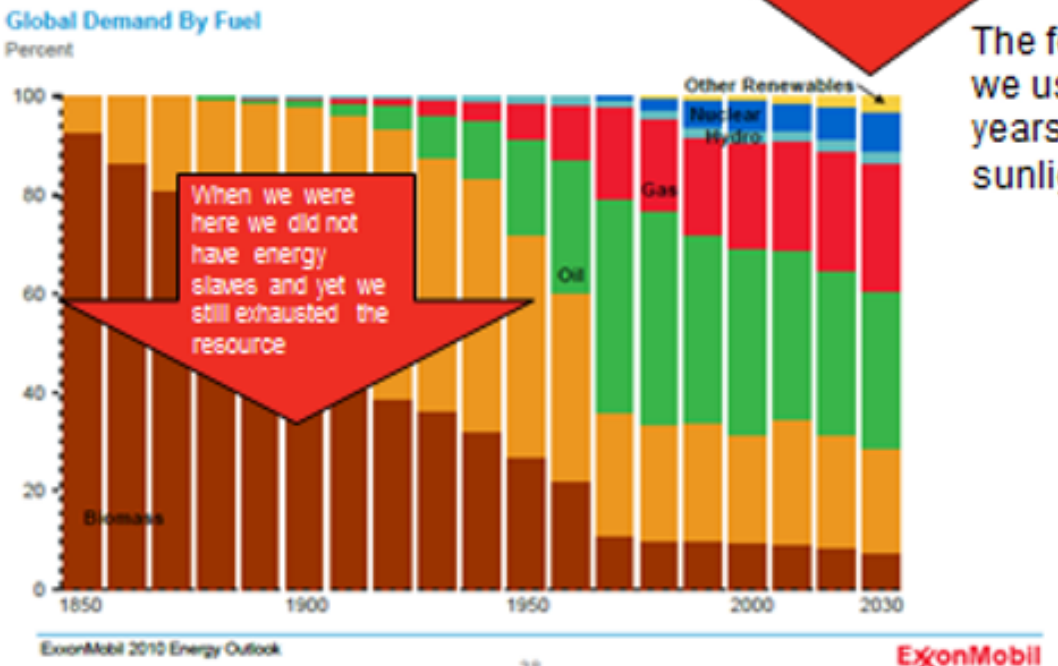
not successful in Alberta

All Electric Net Zero		
(kwh)	**Model**	**Actual**
Space Heating	1,541	10,776
DHW Heating	1,533	3,622
Lights & Appliances	6,205	5,531
Ventilation & Fans	1,606	1,076
Air Conditioning	225	4
Total Energy	11,110	21,008
Solar Generation	11,110	11,962
Net Energy	0	9,046
Electric Utility Bill	$600	$2,482
GHG	0.2	5.2
Key Features	Upgraded Envelope	
	Air Source Heat Pump	
	Heat Pump Water Heater	
	10 kw solar	
Incremental Cost	$86,500	


Wealth / Energy In Historical Perspective
All of history up to 1900
Since 1900
Ancient inventory of stored sunlight
- Fossil fuels provide 93% of worlds energy currently
- 5/6 of all fossil fuels have been burnt in the last 55 years
- Hydro power accounts for 1% of energy supply currently
- People and animal labour is approximately 6% of productive energy today
94% of production energy from people and animals


POWERING THE ECONOMY
FUELS
HUMAN LABOR
DOMESTICATED ANIMALS
1850
1870
1890
1910
1930
1950
1970

Energy Needs Evolve Over Time



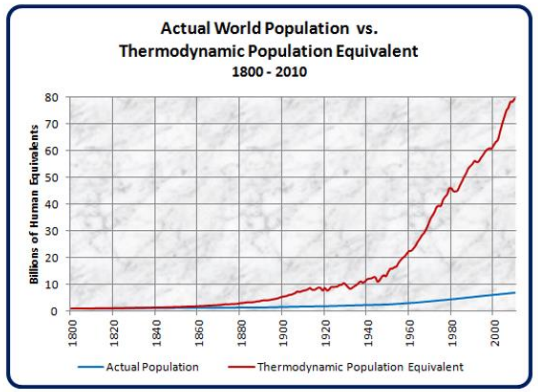
Here shows earths scarcest resource is time

The fossil fuels we use daily = 7 years of stored sunlight

ExxonMobil

Taking on the world's toughest energy challenges

Source: Smil, *Energy Transitions*; ExxonMobil

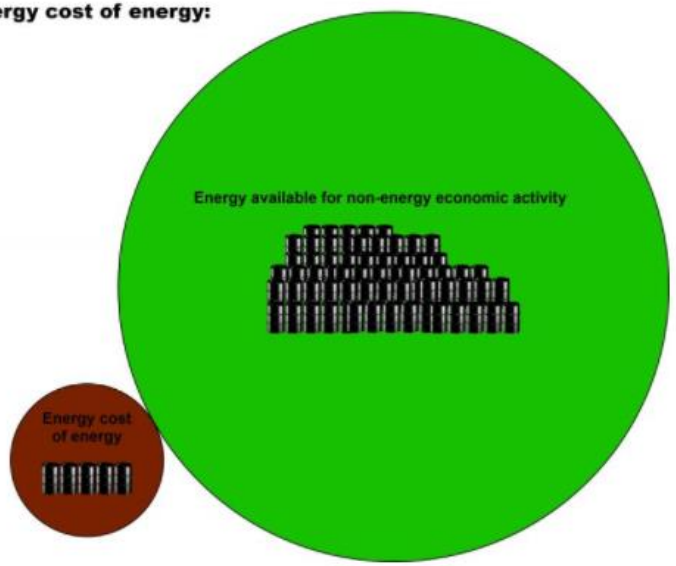


Thermodynamic population equivalent refers to number of people needed to do work that is completed today with appliances and automation

Machine	Horsepower
Man pushing a lever	0.05
Ox pulling a load	0.5
Water wheels	0.5–5
Versailles water works (1600)	75
Newcomen steam engine	5.5
Watt's steam engine	40
Marine steam engine (1850)	1,000
Marine steam engine (1900)	8,000
Steam turbine (1940s)	300,000
Coal or nuclear power plant (1970s)	1,500,000

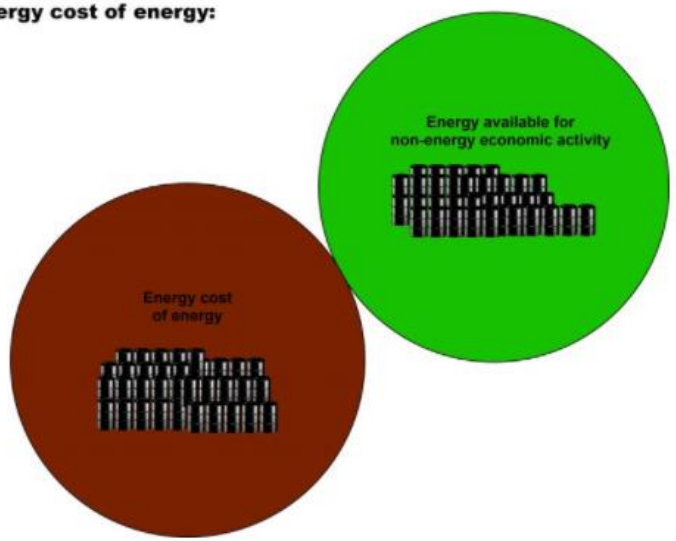
Source: Cook [33]

Low energy cost of energy:



If, then, the *energy cost* of energy increases – i.e. we have to divert more energy away from the non-energy economy; the non-energy economy *must* shrink:

High energy cost of energy:



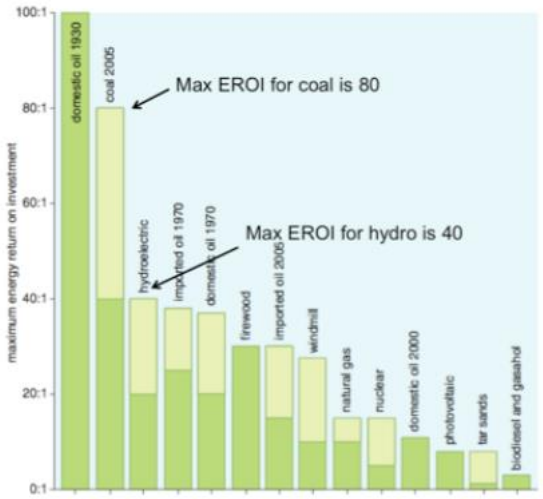
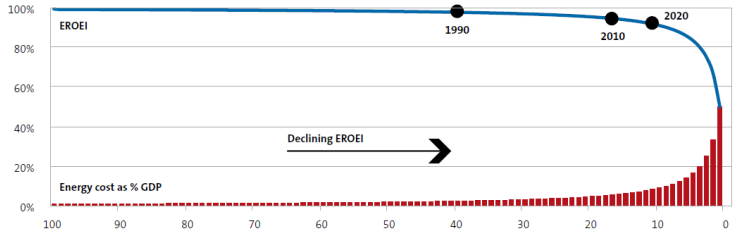
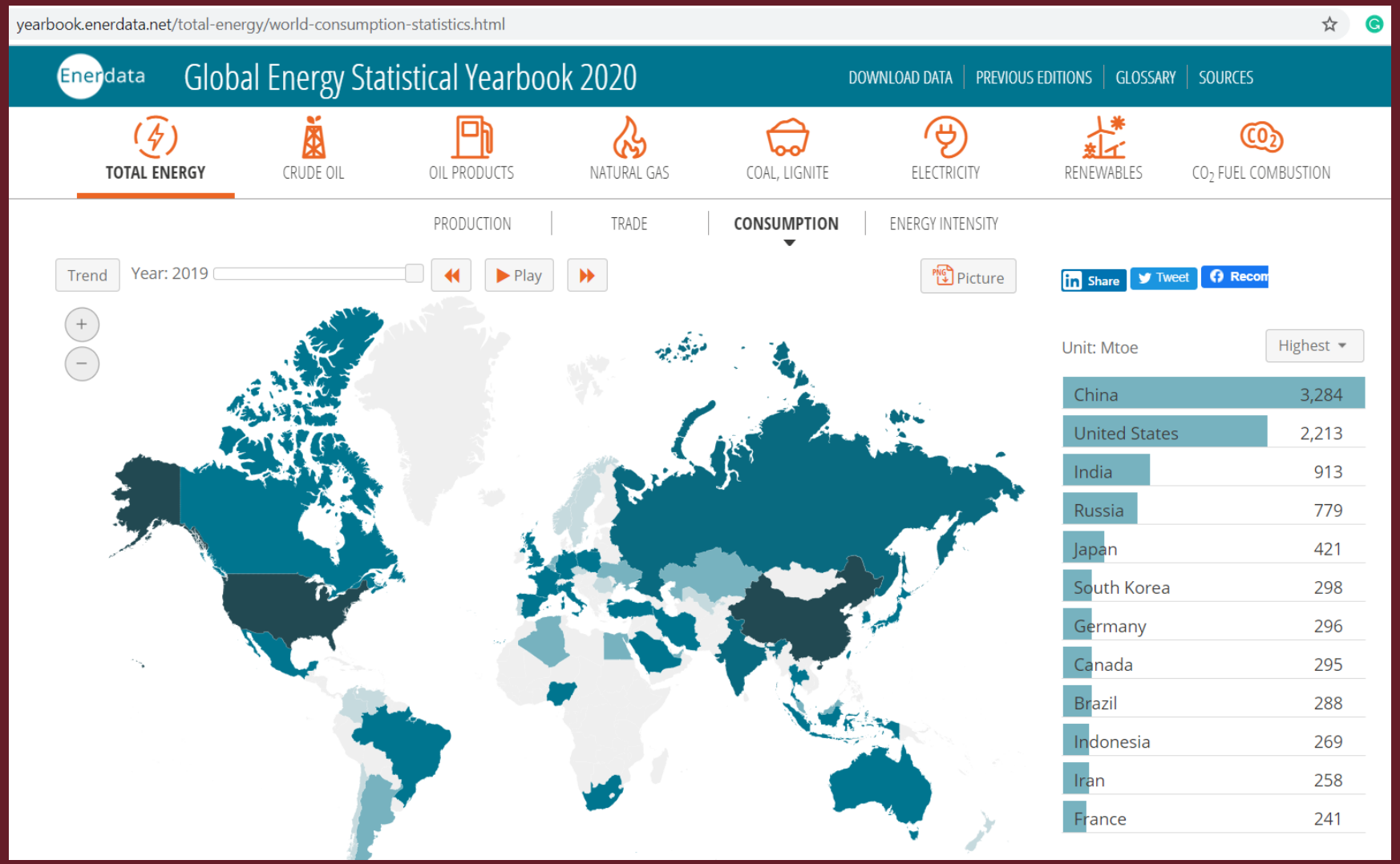


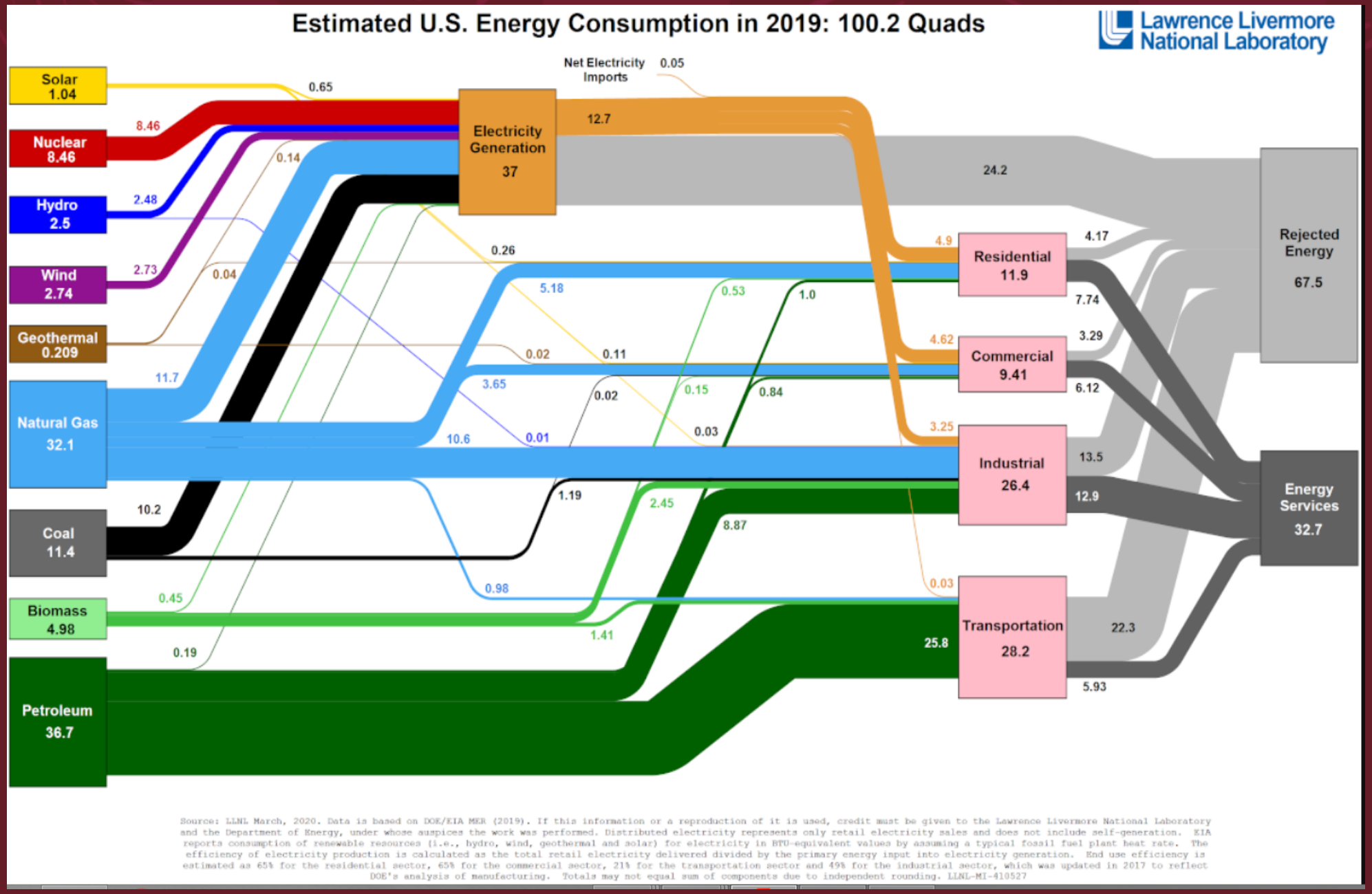
Fig. 1.5: Nearing the energy returns cliff-edge*



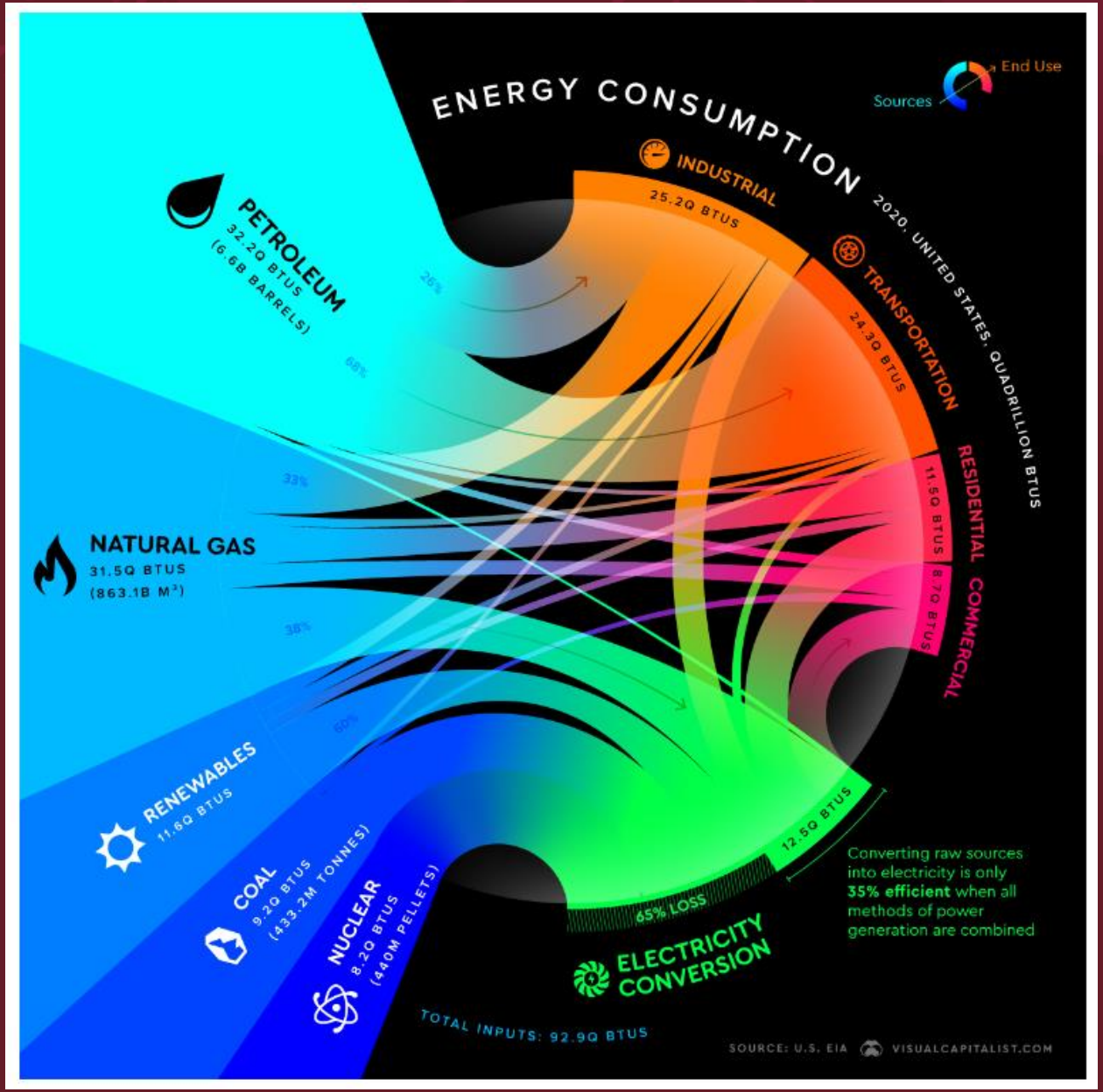
* Source: Tullett Prebon analysis

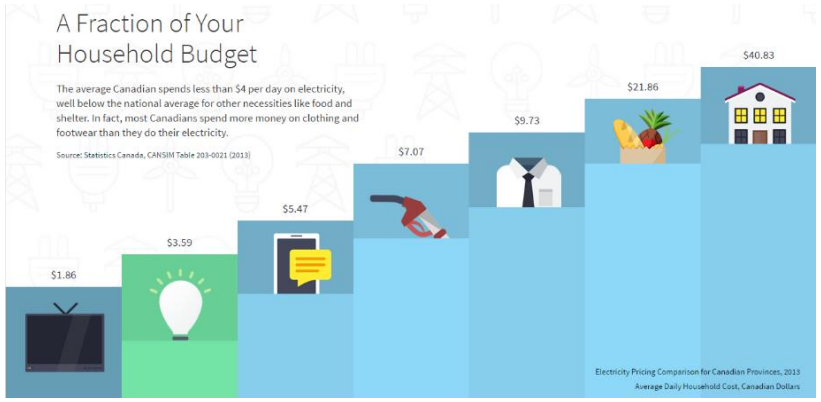
https://yearbook.enerdata.net/

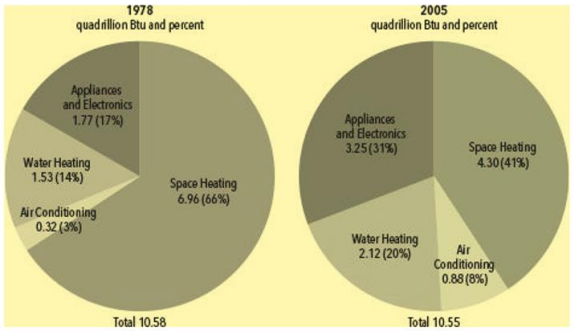




Cogeneration, etc. can drive efficiencies here

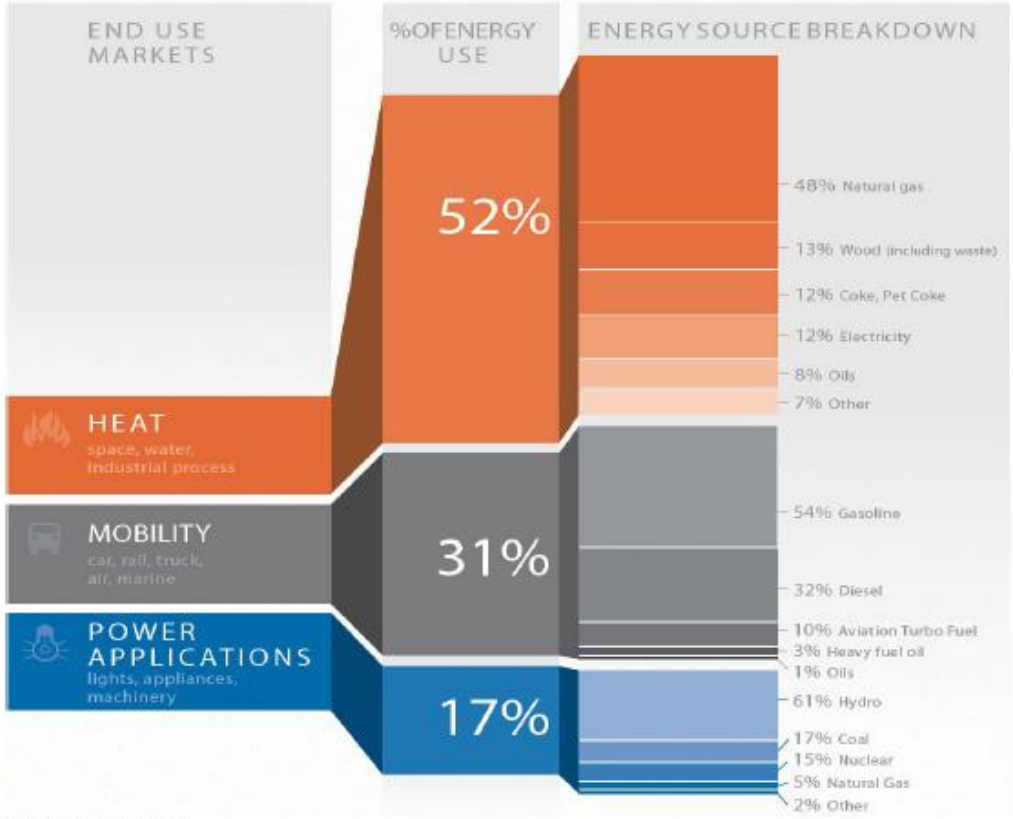

ENERGY CONSUMPTION
2020, UNITED STATES, QUADRILLION BTUS
Sources
End Use
PETROLEUM
32.2Q BTUS
(6.6B BARRELS)
NATURAL GAS
31.5Q BTUS
(863.1B M³)
RENEWABLES
11.6Q BTUS
COAL
9.2Q BTUS
(433.2M TONNES)
NUCLEAR
8.2Q BTUS
(440M PELLETS)
INDUSTRIAL
25.2Q BTUS
TRANSPORTATION
24.3Q BTUS
RESIDENTIAL
11.5Q BTUS
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





U.S. residential energy use

HOW CANADA USES ENERGY: HEAT, MOBILITY, POWER



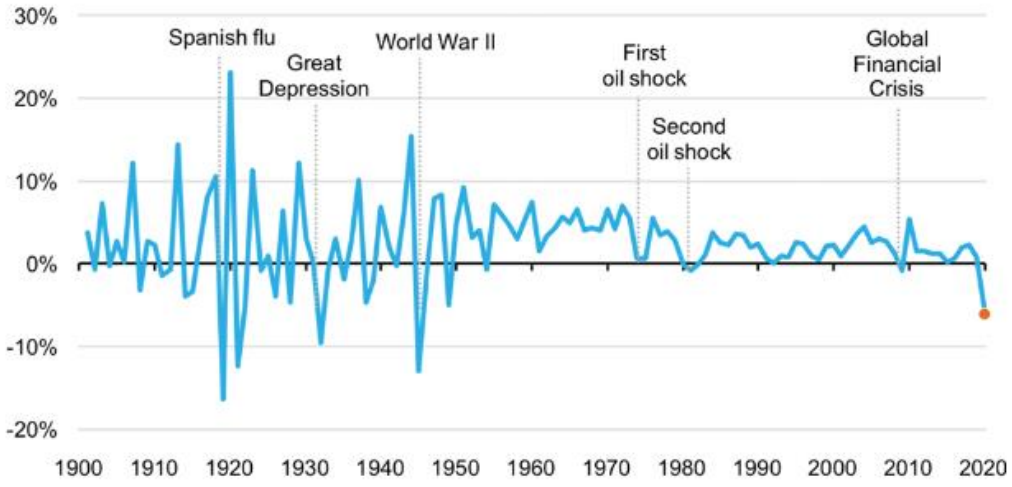
CANADIAN GAS ASSOCIATION
ASSOCIATION CANADIENNE DU GAZ

In Perspective: 2019 Energy Use

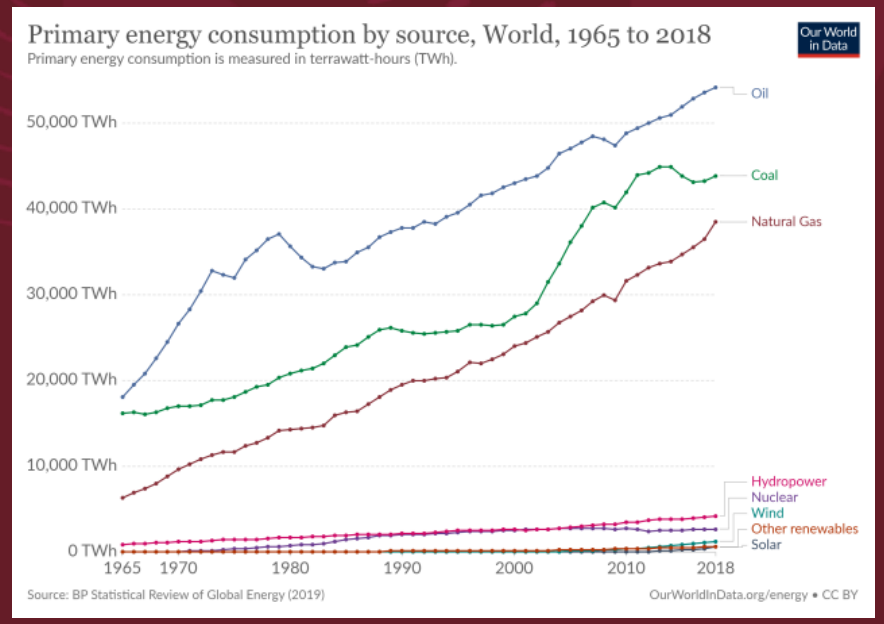
Below, we'll use the unit of **quads**, with each quad worth 1 quadrillion BTUs, to compare data for the last five years of energy use in the United States. Each quad has roughly the same amount of energy as contained in 185 million barrels of crude oil.

Year	Energy Consumption	Change (yoy)	Fossil Fuels in Mix
2019	100.2 quads	-1.0	80.0%
2018	101.2 quads	+3.5	80.2%
2017	97.7 quads	+0.4	80.0%
2016	97.3 quads	+0.1	80.8%
2015	97.2 quads	-1.1	81.6%

FIGURE 1: RATE OF CHANGE OF GLOBAL PRIMARY ENERGY DEMAND (1900-2020)



Source: International Energy Agency (2020). *Global Energy Review 2020*. All rights reserved.


Primary energy consumption by source, World, 1965 to 2018
Primary energy consumption is measured in terrawatt-hours (TWh).
Our World in Data
50,000 TWh
40,000 TWh
30,000 TWh
20,000 TWh
10,000 TWh
0 TWh
1965
1970
1980
1990
2000
2010
2018
Oil
Coal
Natural Gas
Hydropower
Nuclear
Wind
Other renewables
Solar
Source: BP Statistical Review of Global Energy (2019)
OurWorldInData.org/energy • CC BY

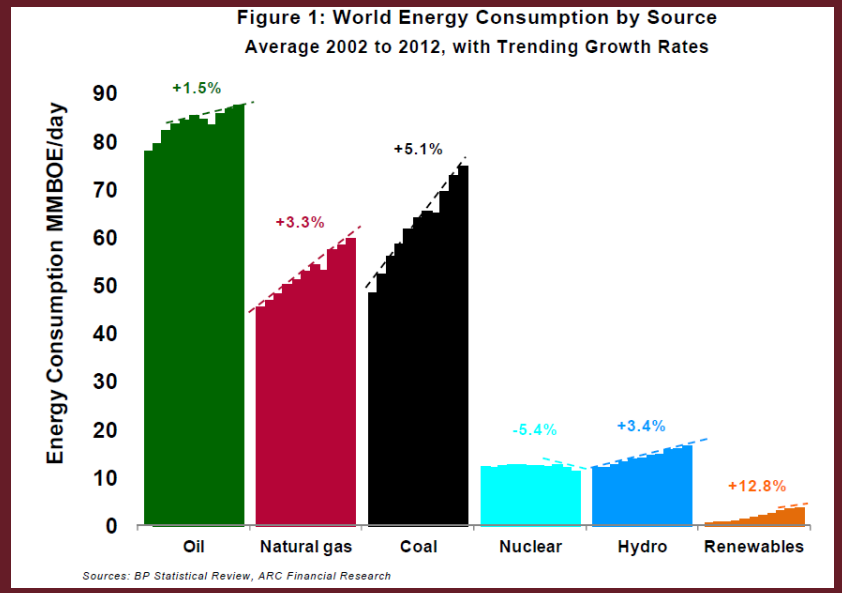
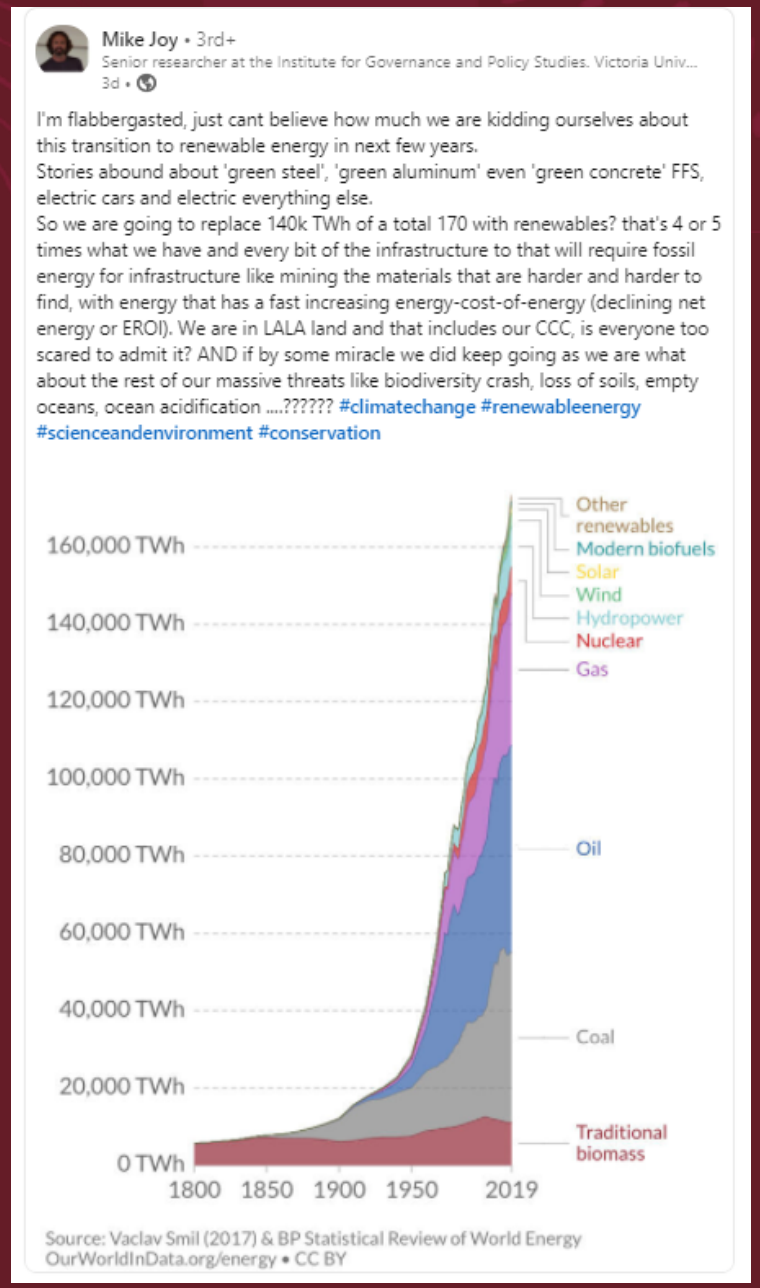
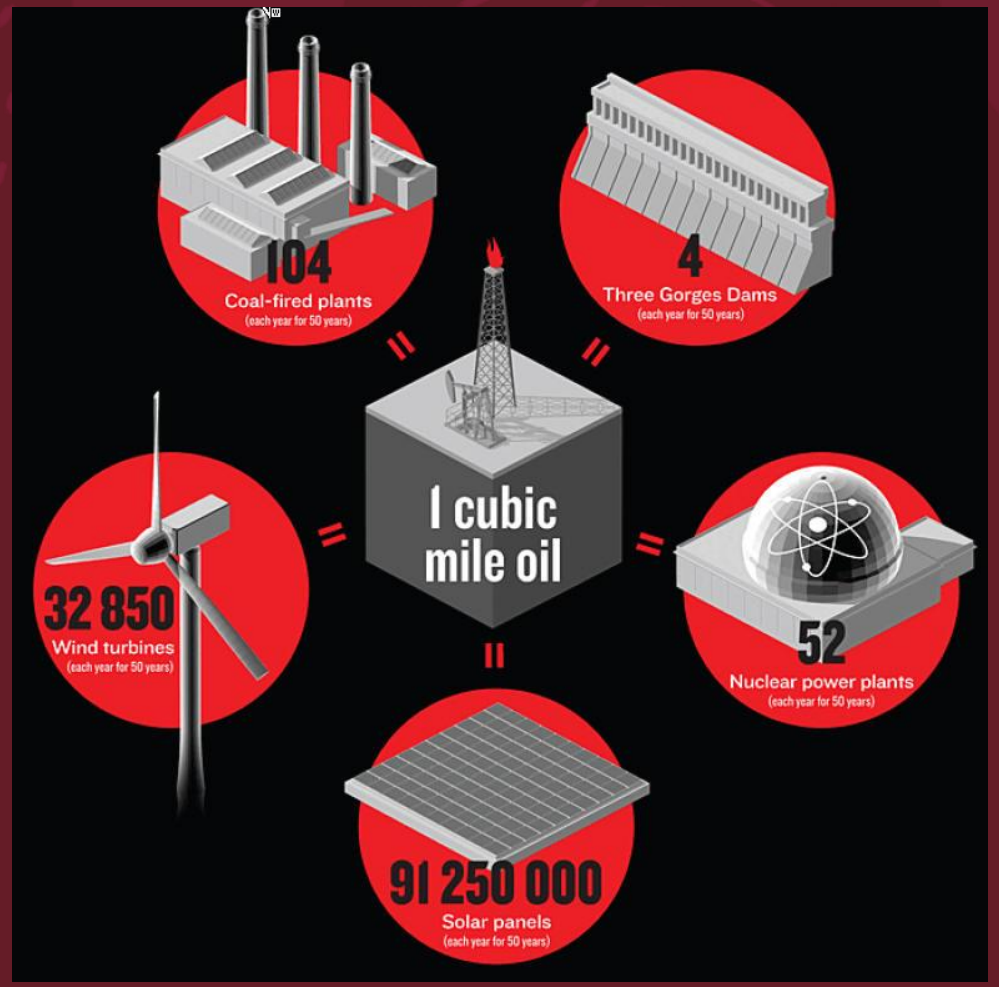


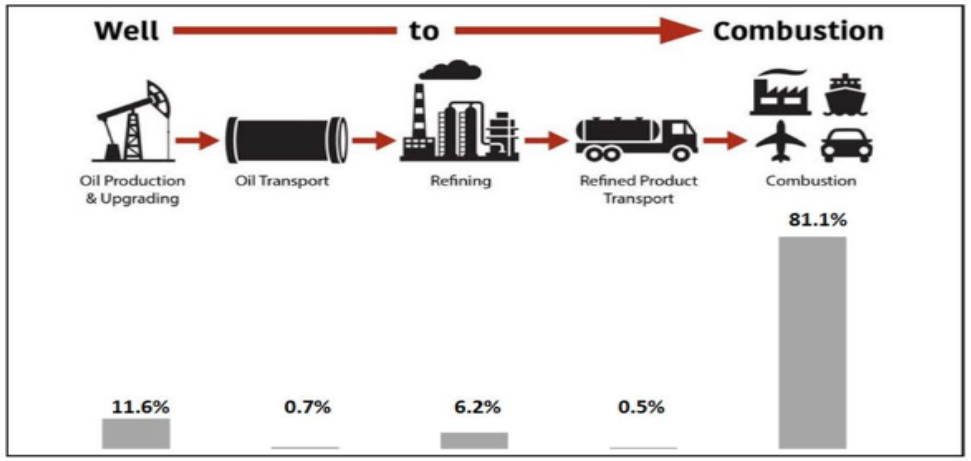
Figure 1: World Energy Consumption by Source
Average 2002 to 2012, with Trending Growth Rates
Energy Consumption MMBOE/day
90
80
70
60
50
40
30
20
10
0
+1.5%
+3.3%
+5.1%
-5.4%
+3.4%
+12.8%
Oil
Natural gas
Coal
Nuclear
Hydro
Renewables
Sources: BP Statistical Review, ARC Financial Research


Mike Joy • 3rd+
Senior researcher at the Institute for Governance and Policy Studies. Victoria Univ...
3d •
I'm flabbergasted, just cant believe how much we are kidding ourselves about this transition to renewable energy in next few years.
Stories abound about 'green steel', 'green aluminum' even 'green concrete' FFS, electric cars and electric everything else.
So we are going to replace 140k TWh of a total 170 with renewables? that's 4 or 5 times what we have and every bit of the infrastructure to that will require fossil energy for infrastructure like mining the materials that are harder and harder to find, with energy that has a fast increasing energy-cost-of-energy (declining net energy or EROI). We are in LALA land and that includes our CCC, is everyone too scared to admit it? AND if by some miracle we did keep going as we are what about the rest of our massive threats like biodiversity crash, loss of soils, empty oceans, ocean acidification ....?????? #climatechange #renewableenergy #scienceandenvironment #conservation
160,000 TWh
140,000 TWh
120,000 TWh
100,000 TWh
80,000 TWh
60,000 TWh
40,000 TWh
20,000 TWh
0 TWh
1800
1850
1900
1950
2019
Other renewables
Modern biofuels
Solar
Wind
Hydropower
Nuclear
Gas
Oil
Coal
Traditional biomass
Source: Vaclav Smil (2017) & BP Statistical Review of World Energy
OurWorldInData.org/energy • CC BY



- Every day the world uses 98 million barrels of oil, 328 BCF of natural gas, 15 million tons of coal, 200,000 kilograms of uranium, 10.4TWh of hydroelectricity and millions of hectares of wind farms, solar panels, forests and cornfields.
- One cubic mile of oil (CMO) equals the oil that the world consumes every year. Three CMOs equal the energy that the world consumes every year. (More precisely, one CMO equals global oil consumption in 2000; by 2006, consumption had increased to 1.06 CMO.)

Estimated Well-to-Combustion GHG Emissions From Crude Oil
US Refined Average (2014)



Source: ARC Energy Research Institute. "Crude Oil Investing in a Carbon Constrained World" October 2017. Using Data from DOE/NETL for characterizing production and upgrading emissions.

Figure 1: Use of carbon tax revenues by high-income OECD countries

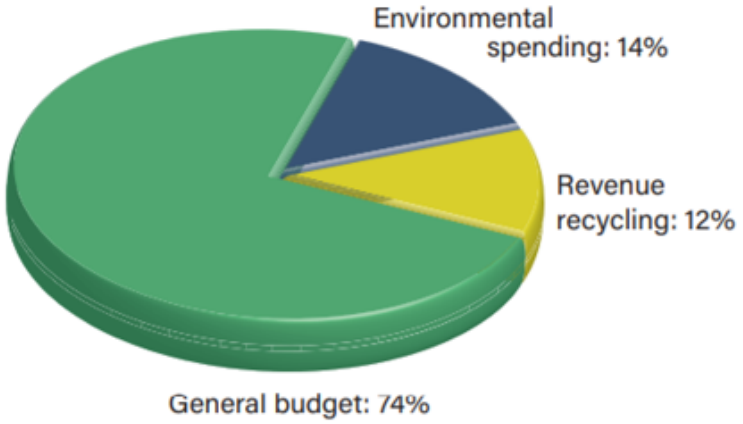


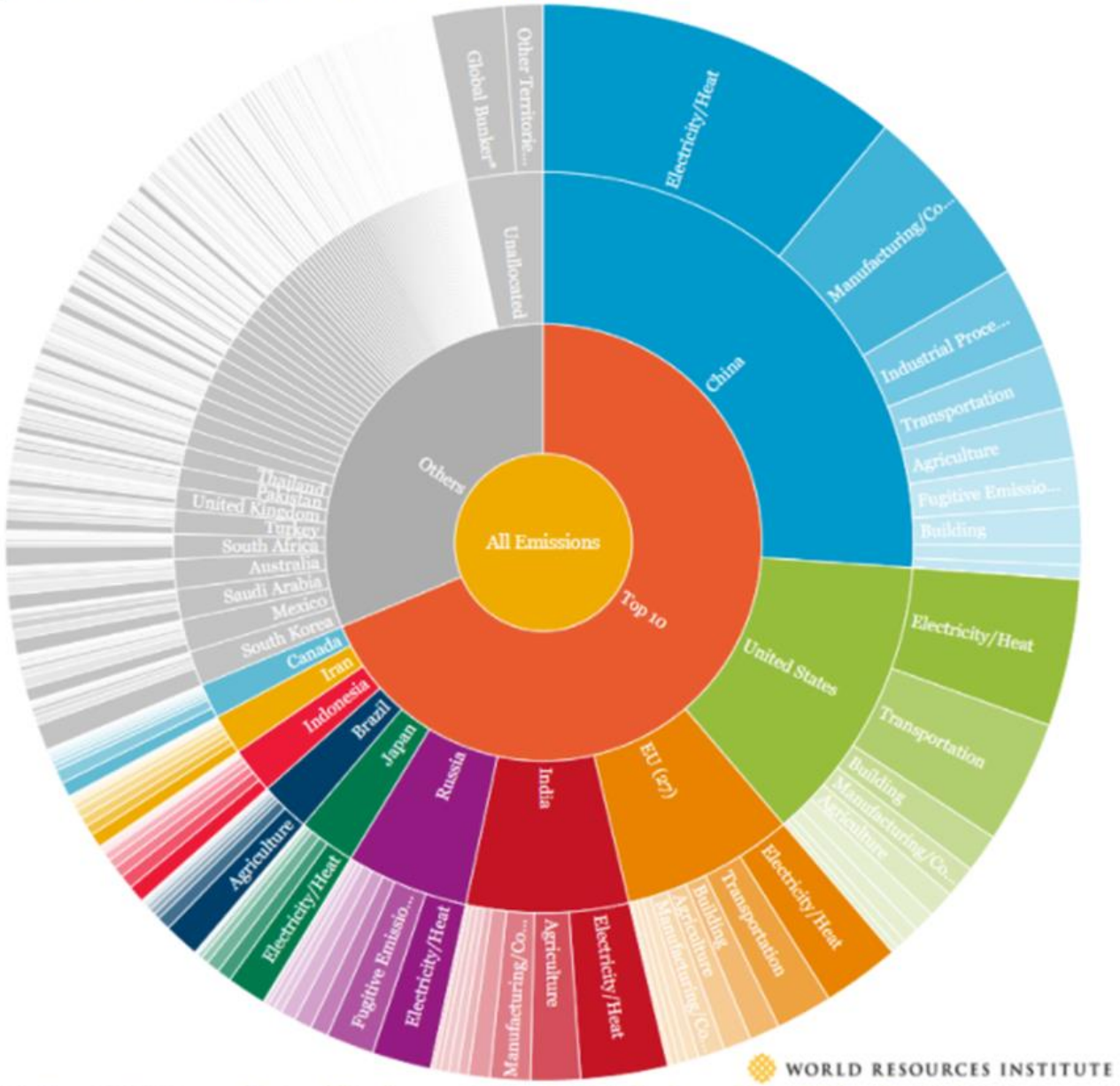
Table 2: Use of carbon tax revenues by high-income OECD countries (latest available data)

Country	Environmental spending (%)	Revenue recycling (%)	General budget (%)
Canada	10	90	0

The Top 10 GHG Emitters Contribute Over Two-Thirds of Global Emissions

Embed

Explore the Latest Global Greenhouse Gas Emissions Data on Climate Watch



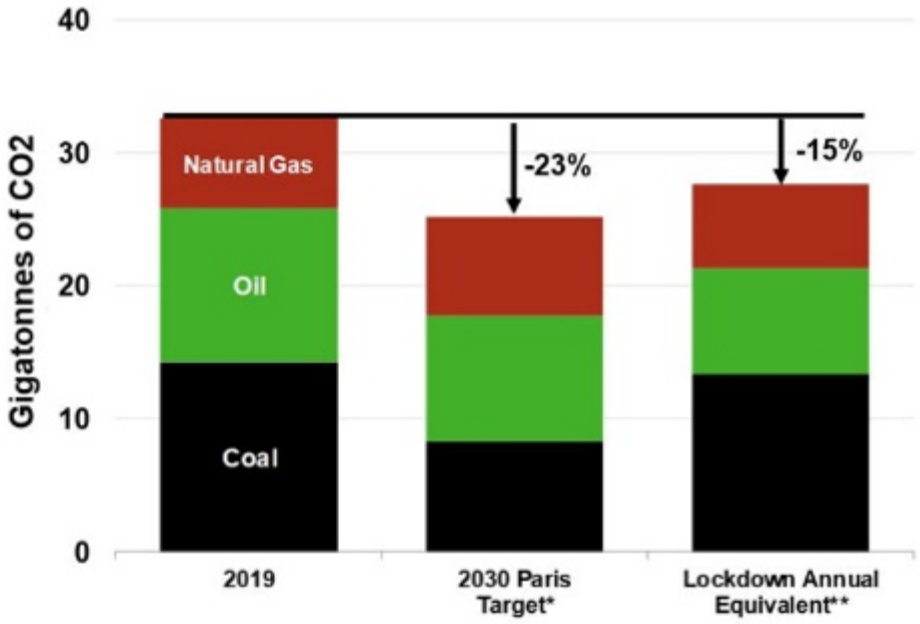
Graphic by Johannes Friedrich. Data source: Preliminary global greenhouse gas emissions 2018 excluding land-use change and forestry (LUCF) from Climate Watch. The EU 27 is considered a country.

*Bunker fuels inlcude international aviation and shipping that are not included in country totals. Other territories include regions not covered by Climate Watch country data. See Climate Watch for country level land-use change and forestry and bunker fuel emissions.

SnapChart - "The World is Locked Down, Yet the Paris Target is Still Out of Reach"

GHG Emissions From Fossil Fuels

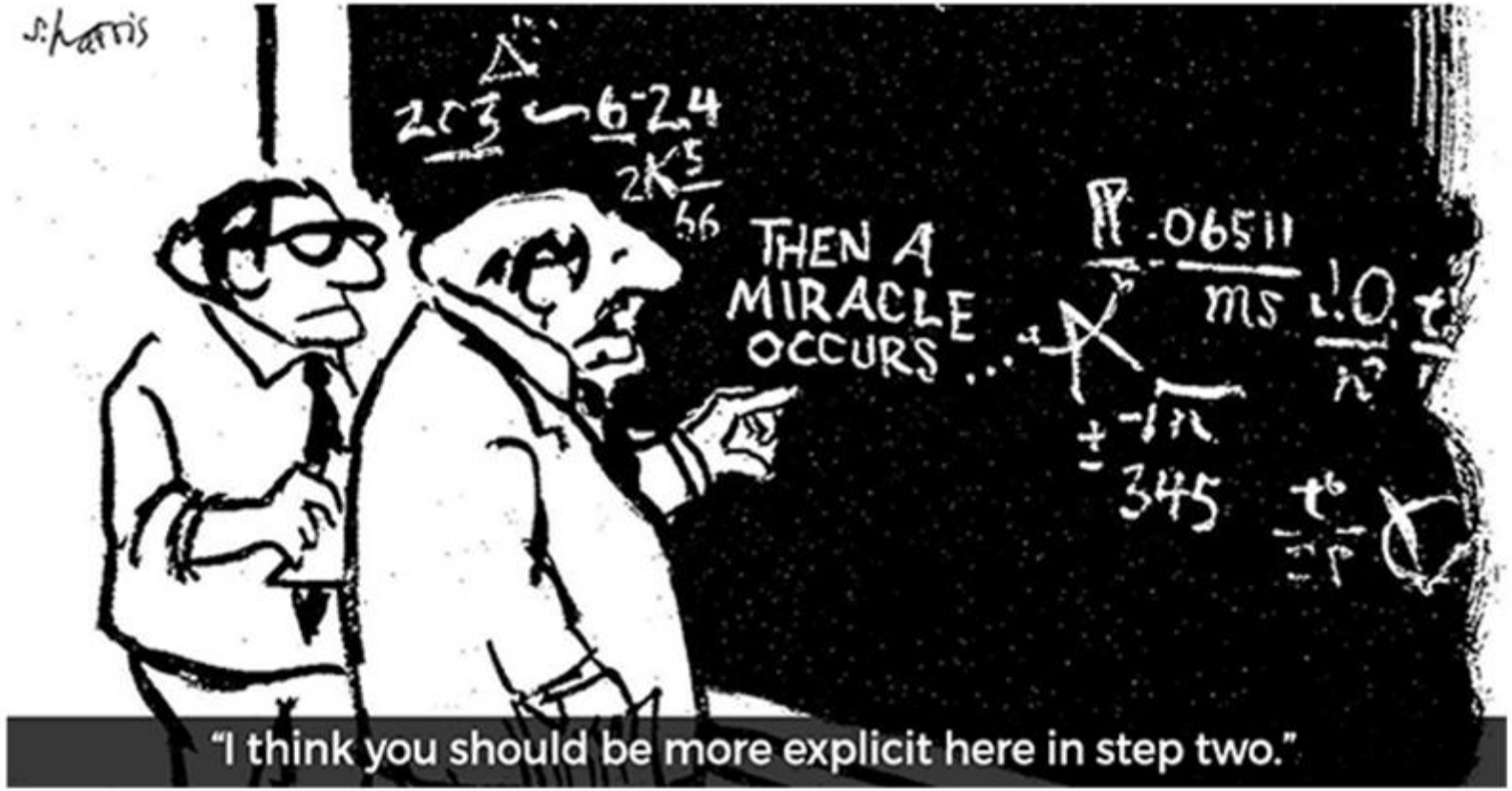
Relative to Paris Targets

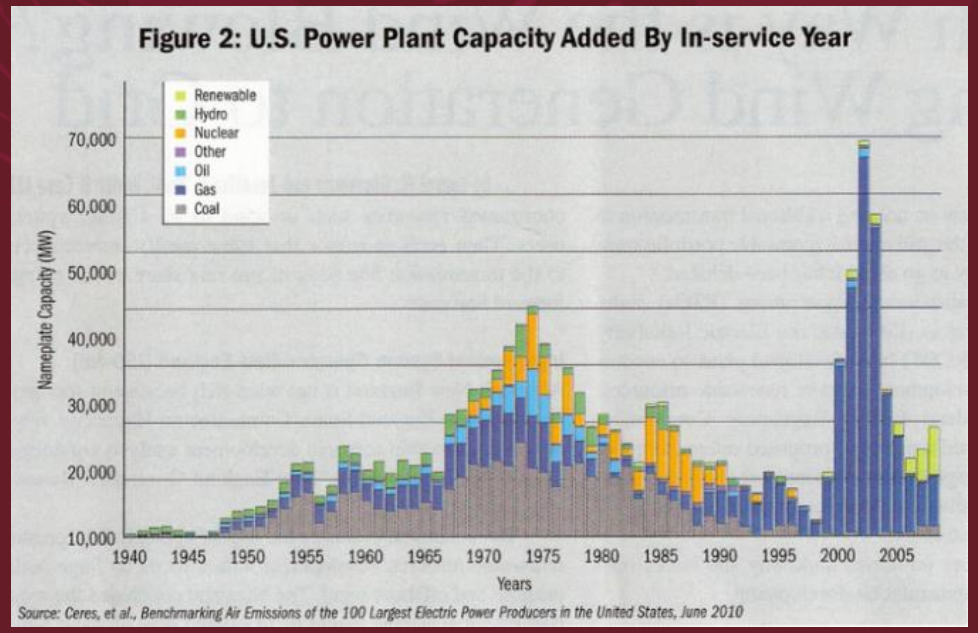


Electricity

GLOBAL ELECTRICITY DEMAND WILL INCREASE BY 62 PER CENT — FROM 25,000 TERAWATT-HOURS IN 2017 TO 38,700 BY 2050

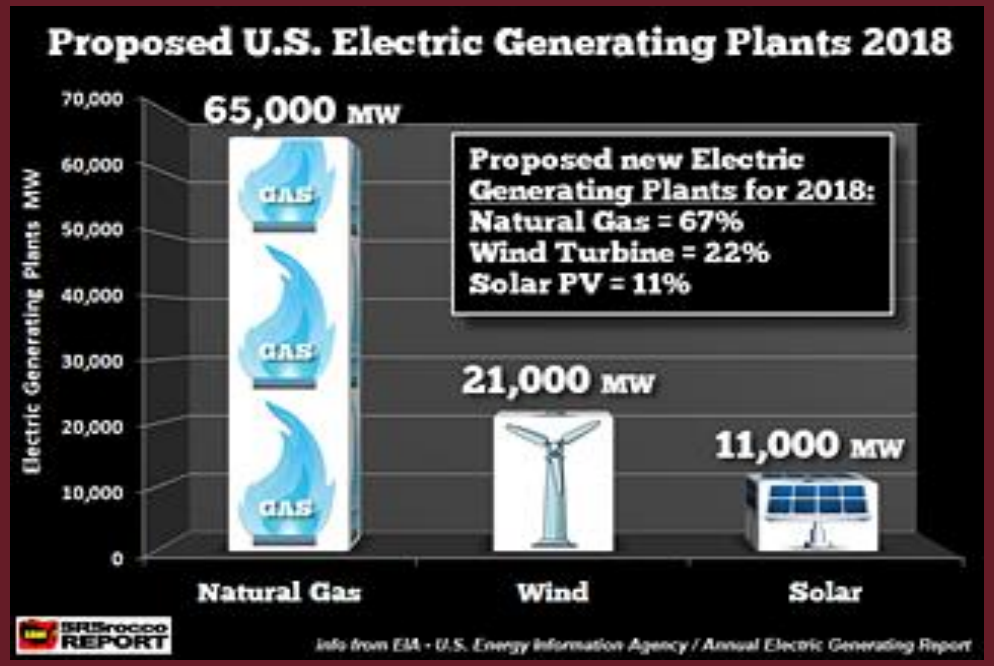
Source: Bloomberg 2020

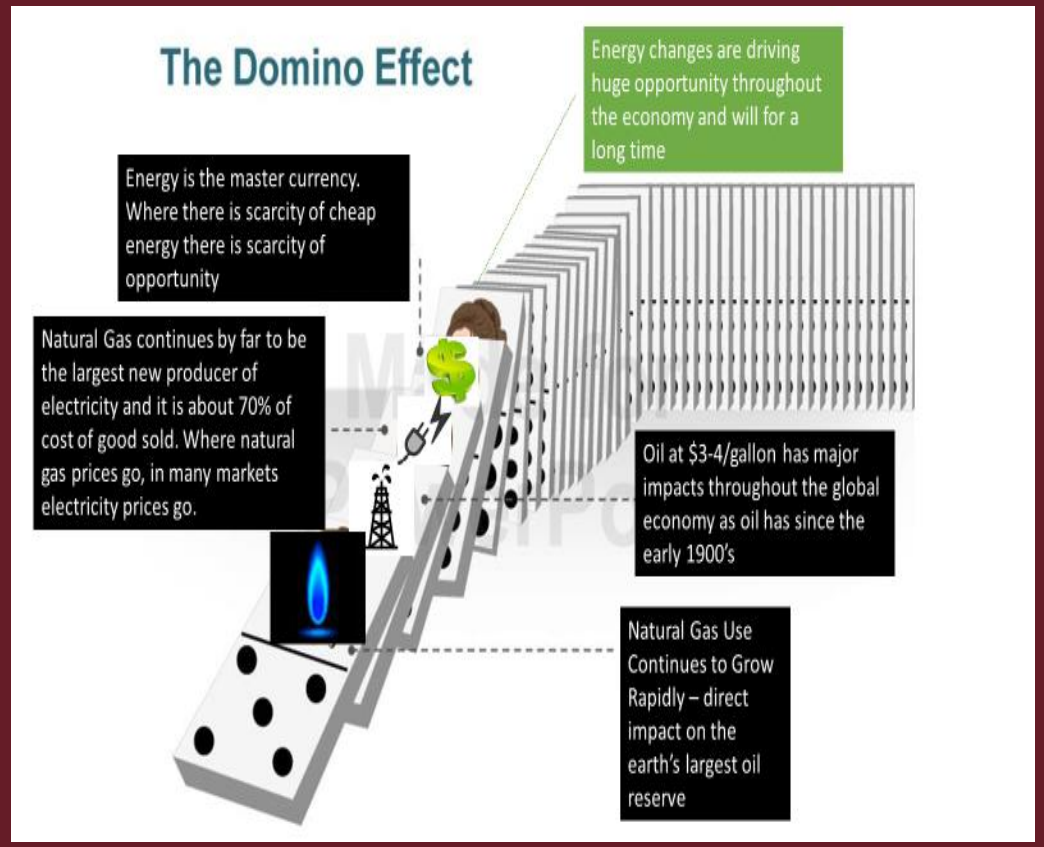




	Electricity Generation (TWh)	Growth rate (%)	Shares (%)	
	2019	2018-19	2000	2019
Total Generation	26 951	1.3%	100%	100%
Coal	9 819	-3.1%	39%	36%
Oil	789	-1.4%	8%	3%
Gas	6 246	2.5%	18%	23%
Nuclear	2 806	3.3%	17%	10%
Hydro	4 333	2.4%	17%	16%
Biomass and waste	688	7.8%	1%	3%
Wind	1 405	11.9%	0%	5%
Solar photovoltaics	720	22.3%	0%	3%
Other renewables	144	5.3%	0%	1%

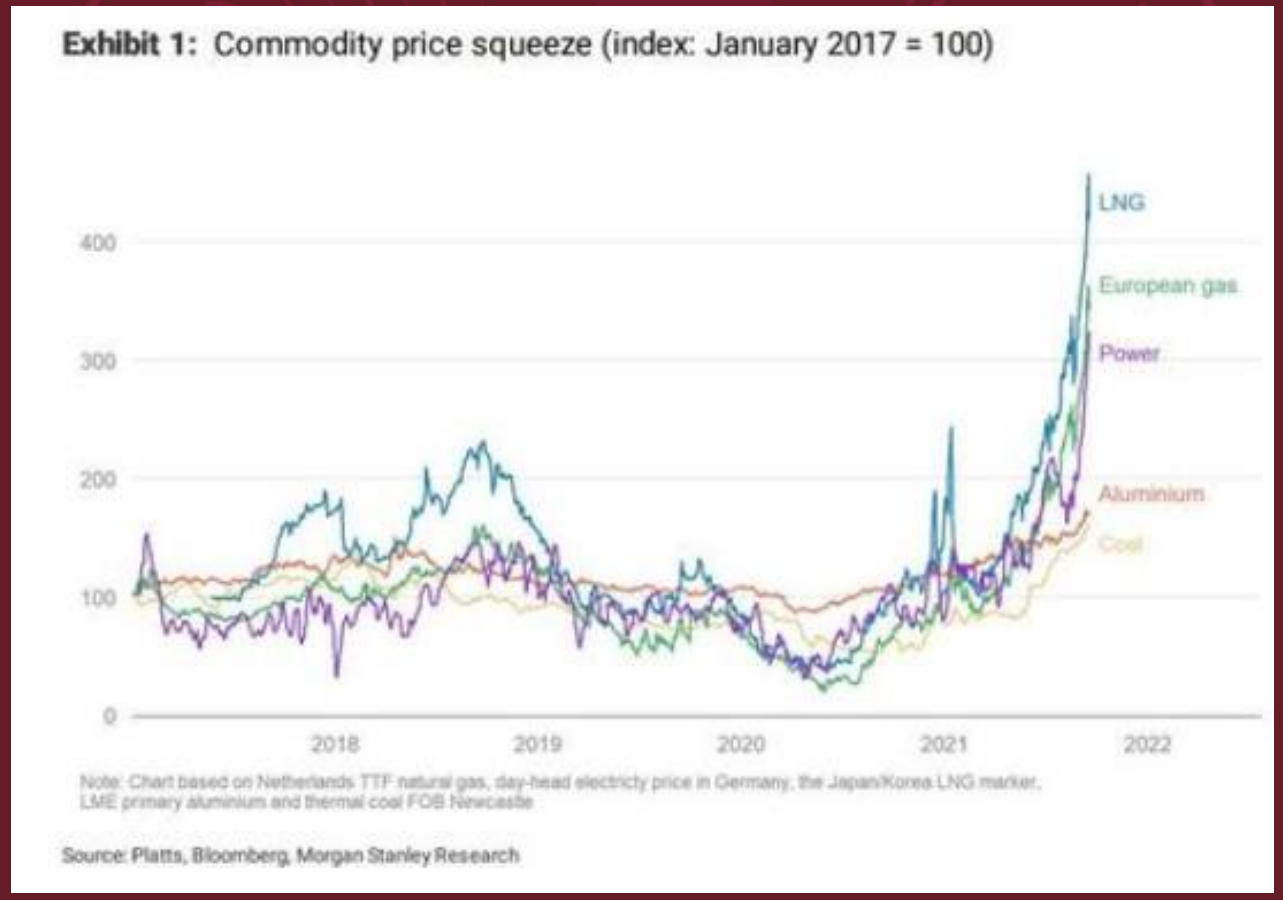
Source: IEA, 'Global Energy Review 2019'

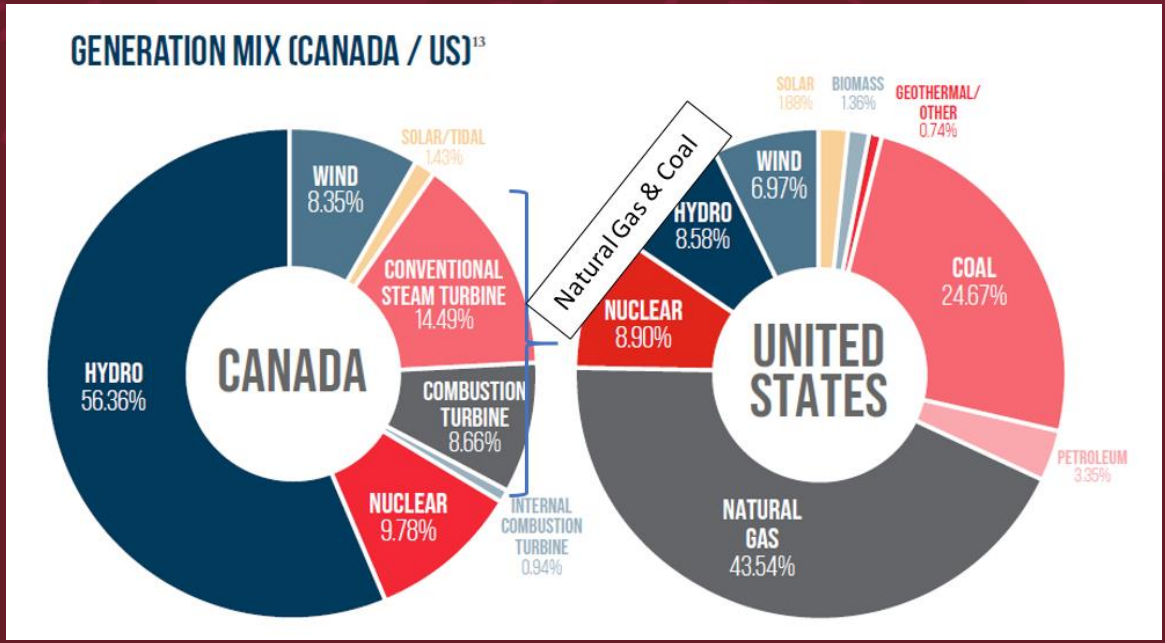


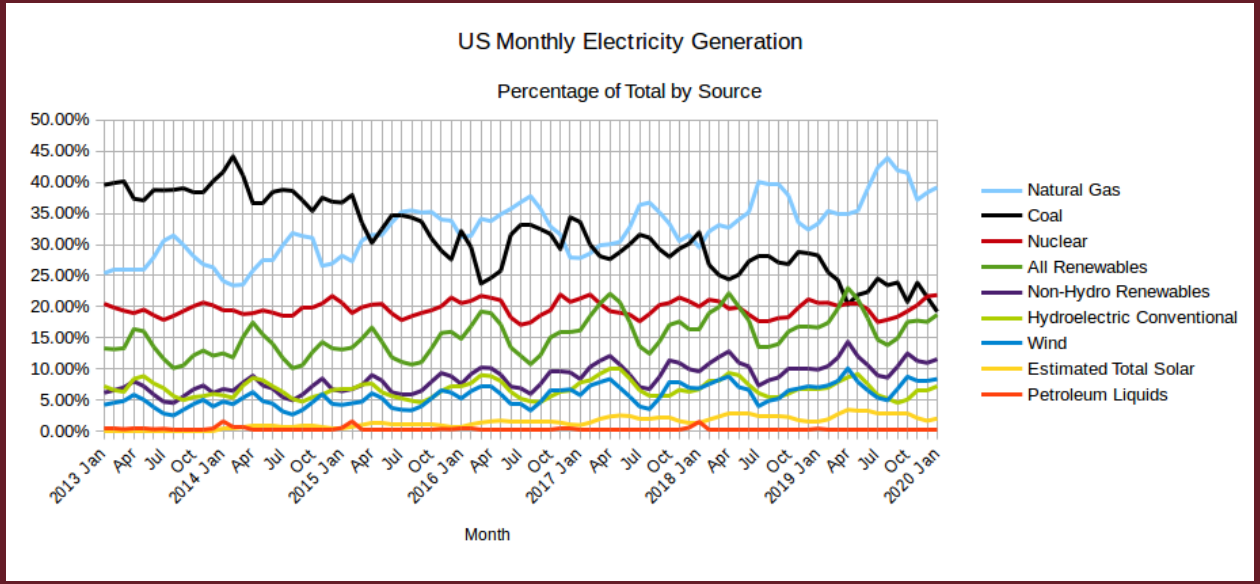


- *Nationally, 450 landfills and 87 incinerators produced about 24 million megawatt-hours of electricity in 2007, about 2 days of U.S. electricity use.*
- *By comparison, wind energy contributes about 3 days of U.S. power a year*
- *Solar produces 76 minutes' worth.*

US Energy Department data, 2009




GENERATION MIX (CANADA / US)[13]
CANADA
HYDRO 56.36%
WIND 8.35%
SOLAR/TIDAL 1.43%
CONVENTIONAL STEAM TURBINE 14.49%
COMBUSTION TURBINE 8.66%
INTERNAL COMBUSTION TURBINE 0.94%
NUCLEAR 9.78%
Natural Gas & Coal
UNITED STATES
SOLAR 1.88%
BIOMASS 1.36%
GEOTHERMAL/ OTHER 0.74%
WIND 6.97%
HYDRO 8.58%
NUCLEAR 8.90%
COAL 24.67%
PETROLEUM 3.35%
NATURAL GAS 43.54%


US Monthly Electricity Generation
Percentage of Total by Source
50.00%
45.00%
40.00%
35.00%
30.00%
25.00%
20.00%
15.00%
10.00%
5.00%
0.00%
2013 Jan
Apr
Jul
Oct
2014 Jan
2015 Jan
2016 Jan
2017 Jan
2018 Jan
2019 Jan
2020 Jan
Month
Natural Gas
Coal
Nuclear
All Renewables
Non-Hydro Renewables
Hydroelectric Conventional
Wind
Estimated Total Solar
Petroleum Liquids

Hydrogen

Water for a Hydrogen Economy: an Alberta case study

How much water is required to produce hydrogen? How much water and hydrogen would be required to replace 20% of the natural gas produced in Alberta? What is the cost of producing hydrogen? A report was recently published by WaterSMART Solutions Ltd. that responds to these questions. The report highlights the importance of water in the development of the hydrogen economy, and particularly begins to consider the tradeoffs that will likely be required with existing water consuming sectors in the province.

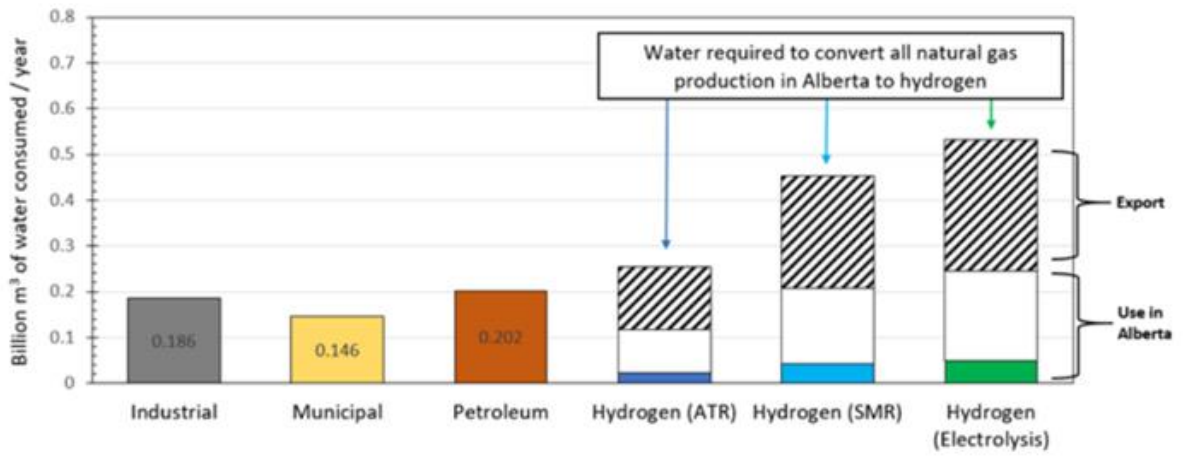
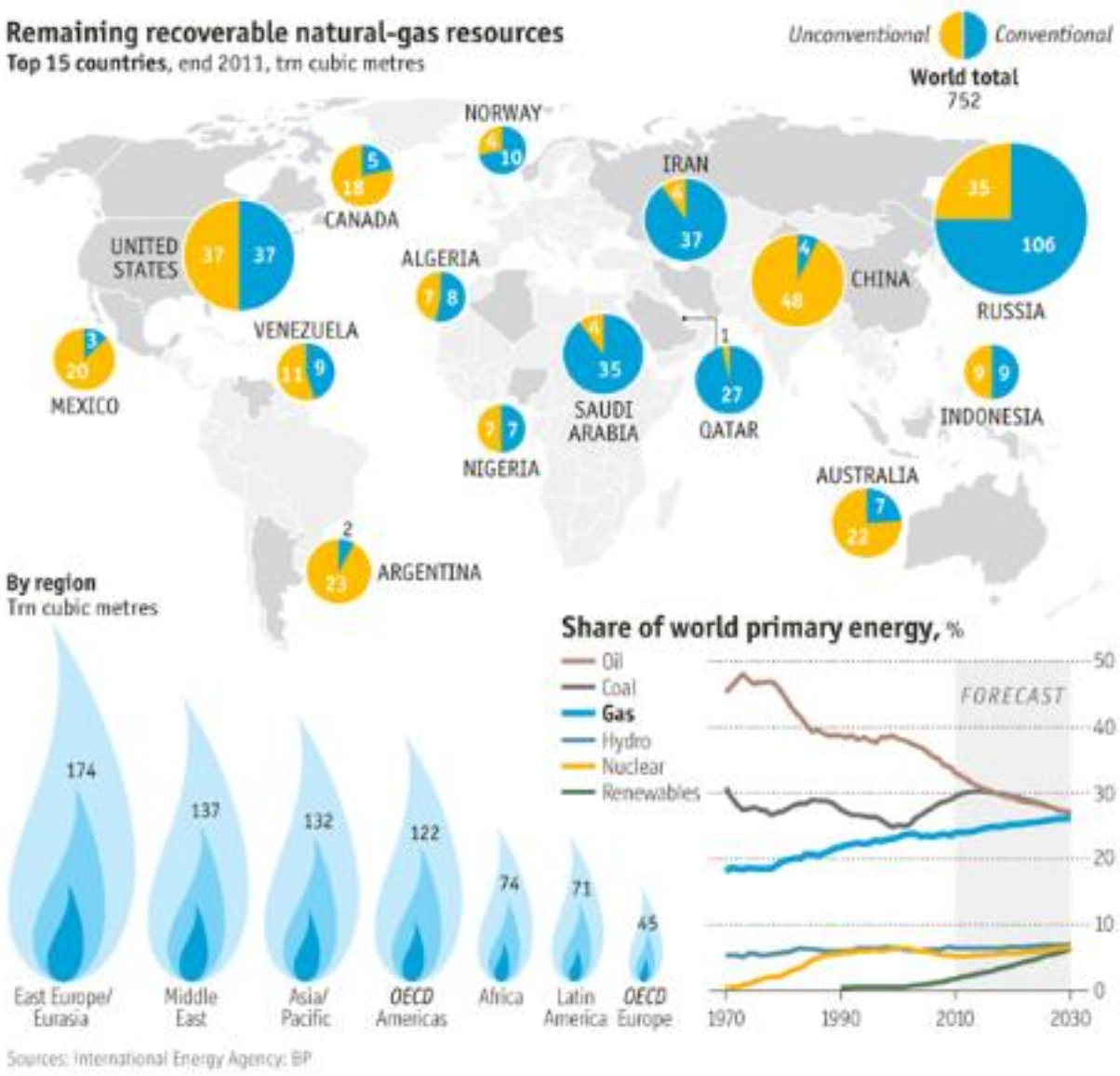
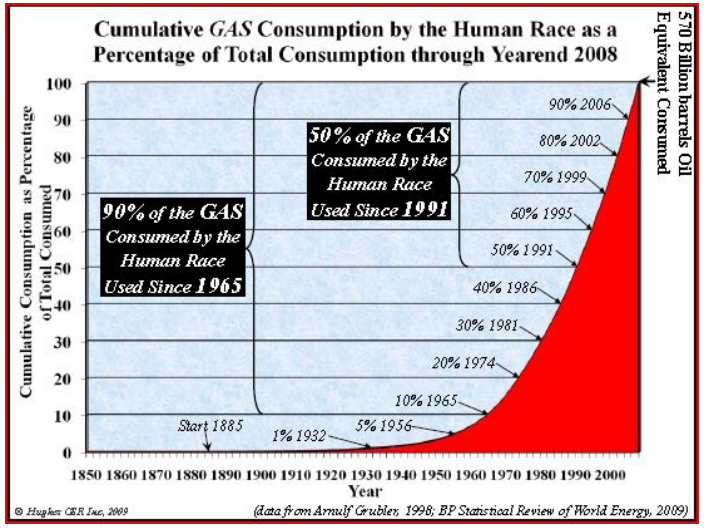


Figure 2: Annual water consumption in Alberta, including projected demands for hydrogen production. Image source: WaterSMART Solutions white paper

Natural Gas

Short Heat Is Trouble


Remaining recoverable natural-gas resources
Top 15 countries, end 2011, trn cubic metres
Unconventional
Conventional
World total
752
NORWAY
4
10
CANADA
5
18
UNITED STATES
37
37
ALGERIA
7
8
IRAN
4
37
CHINA
4
48
RUSSIA
35
106
VENEZUELA
11
9
MEXICO
3
20
SAUDI ARABIA
4
35
QATAR
1
27
INDONESIA
9
9
NIGERIA
7
7
AUSTRALIA
7
22
ARGENTINA
2
23
By region
Trn cubic metres
174
137
132
122
74
71
45
East Europe/ Eurasia
Middle East
Asia/ Pacific
OECD Americas
Africa
Latin America
OECD Europe
Share of world primary energy, %
Oil
Coal
Gas
Hydro
Nuclear
Renewables
FORECAST
50
40
30
20
10
0
1970
1990
2010
2030
Sources: International Energy Agency; BP


Cumulative GAS Consumption by the Human Race as a Percentage of Total Consumption through Yearend 2008
570 Billion barrels Oil Equivalent Consumed
Cumulative Consumption as Percentage of Total Consumed
90% of the GAS Consumed by the Human Race Used Since 1965
50% of the GAS Consumed by the Human Race Used Since 1991
90% 2006
80% 2002
70% 1999
60% 1995
50% 1991
40% 1986
30% 1981
20% 1974
10% 1965
5% 1956
1% 1932
Start 1885
Year
(data from Arnulf Grubler, 1998; BP Statistical Review of World Energy, 2009)

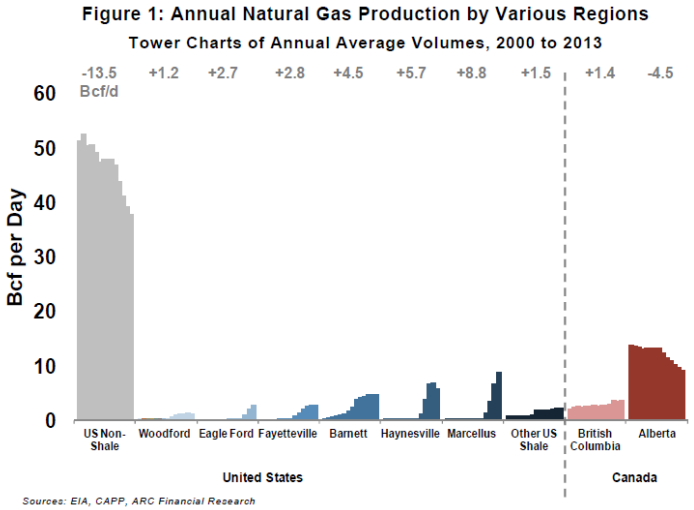
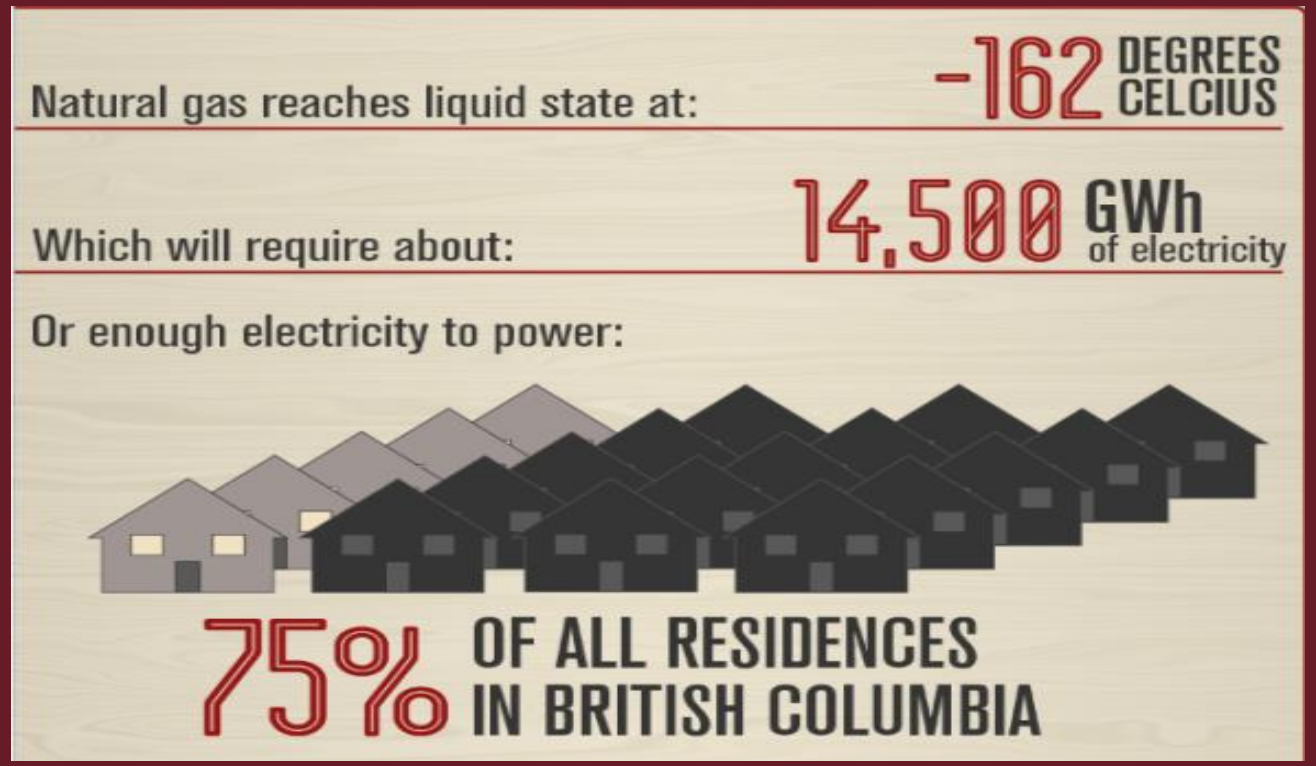
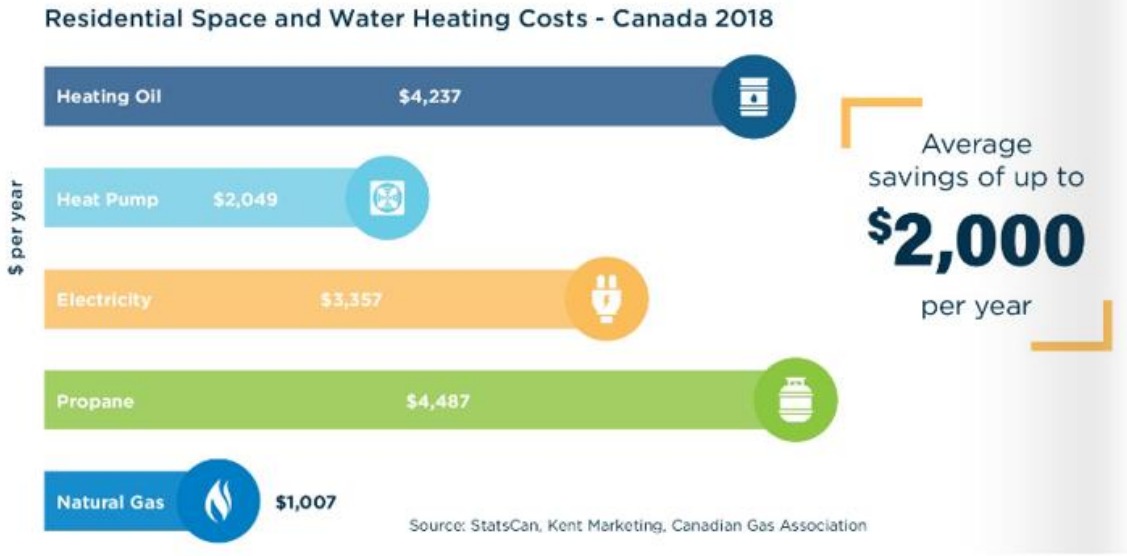


Figure 1: Annual Natural Gas Production by Various Regions
Tower Charts of Annual Average Volumes, 2000 to 2013
-13.5 Bcf/d
+1.2
+2.7
+2.8
+4.5
+5.7
+8.8
+1.5
+1.4
-4.5
Bcf per Day
US Non-Shale
Woodford
Eagle Ford
Fayetteville
Barnett
Haynesville
Marcellus
Other US Shale
British Columbia
Alberta
United States
Canada
Sources: EIA, CAPP, ARC Financial Research

Natural gas exports were the highest for any month since EIA began tracking monthly exports in 1973. Liquefied natural gas (LNG) continues to drive the year-on-year increase in exports. LNG exports in November 2019 were 75.9% higher than in November 2018. In November 2019, the United States exported 6.3 Bcf/d of LNG to 22 countries.

Note the huge energy consumption needed for chilling LNG to enable over seas shipping





Average savings of up to

$2,000

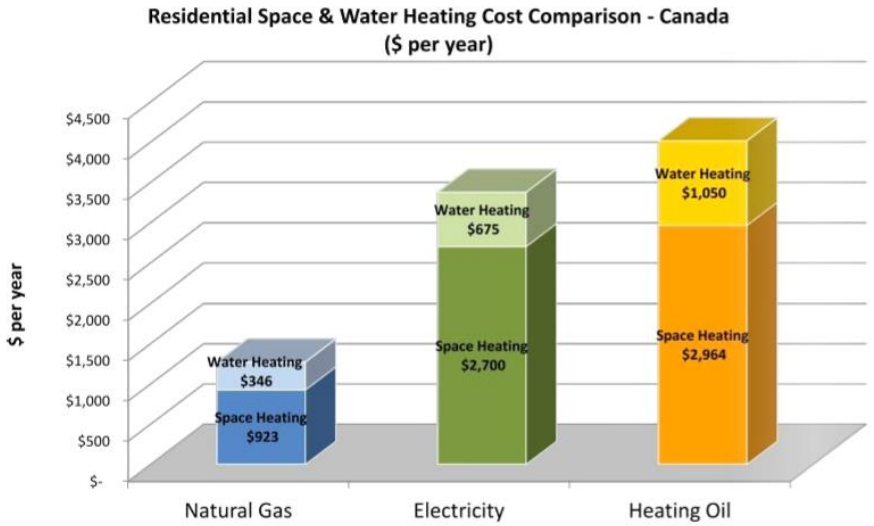
per year

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.

AFFORDABLE – PROVIDING OPPORTUNITIES TO SAVE

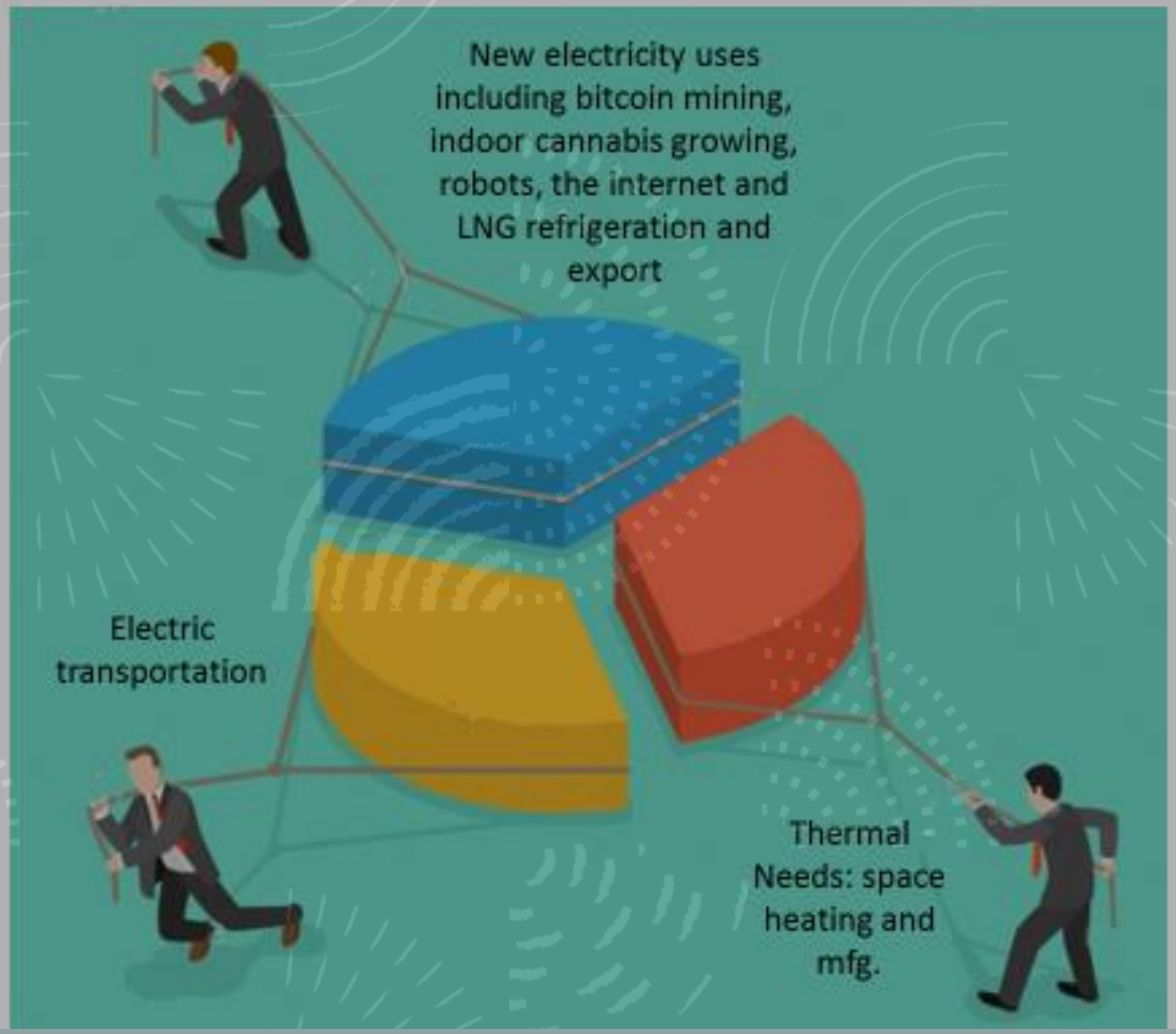


Source: Statistics Canada, Hydro Quebec, Canadian Gas Association

CANADIAN GAS ASSOCIATION
ASSOCIATION CANADIENNE DU GAZ

Competing interests for the finite electricity / natural gas / renewable pie

SEER ENERGY



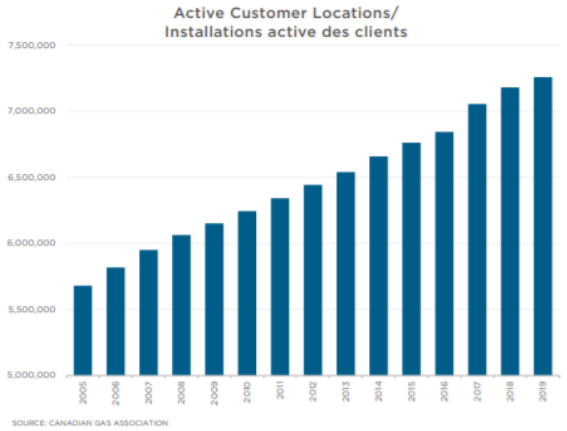
Data centers alone now use 3% of electricity used in the world and growing

NATURAL GAS CUSTOMER BASE

Customers continue to join the natural gas system.

More than 78,000 new customers joined the natural gas system this past year, in preparation for the 2020–21 winter heating season. This brings the total active natural gas customer base of CGA member companies to just over 7.2 million end-use locations.

Over 6.5 million households in Canada use natural gas as their primary heating source. That is more than electricity, heating oil, or propane.



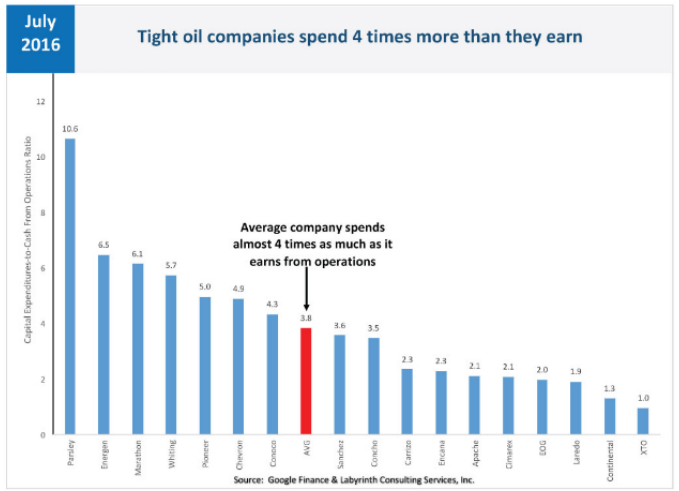
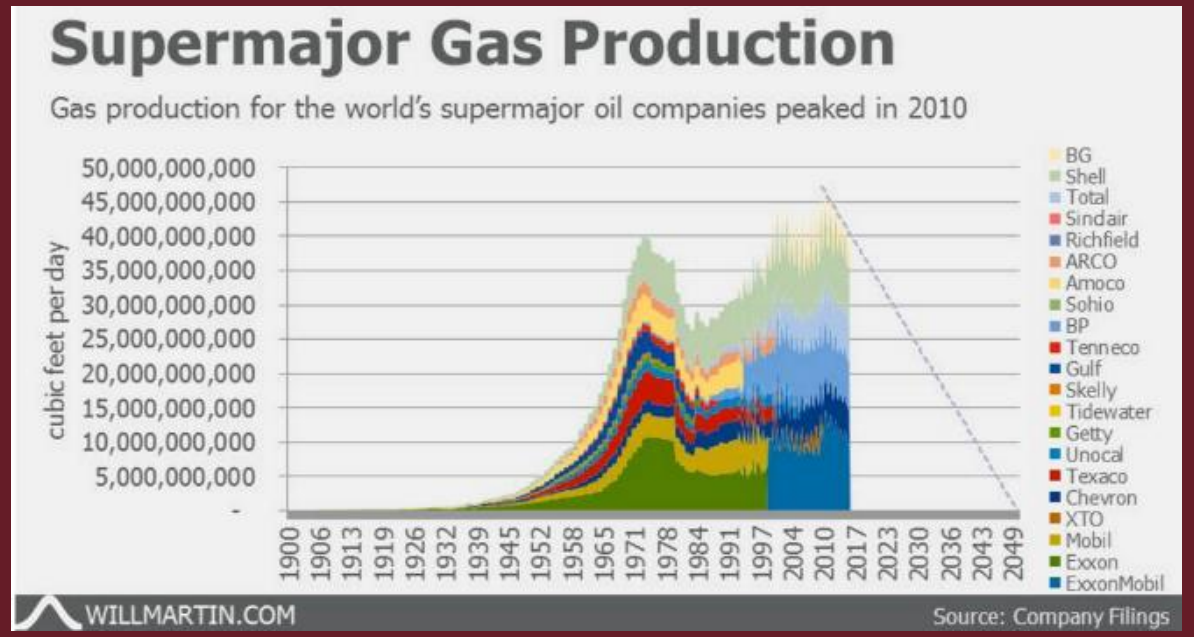
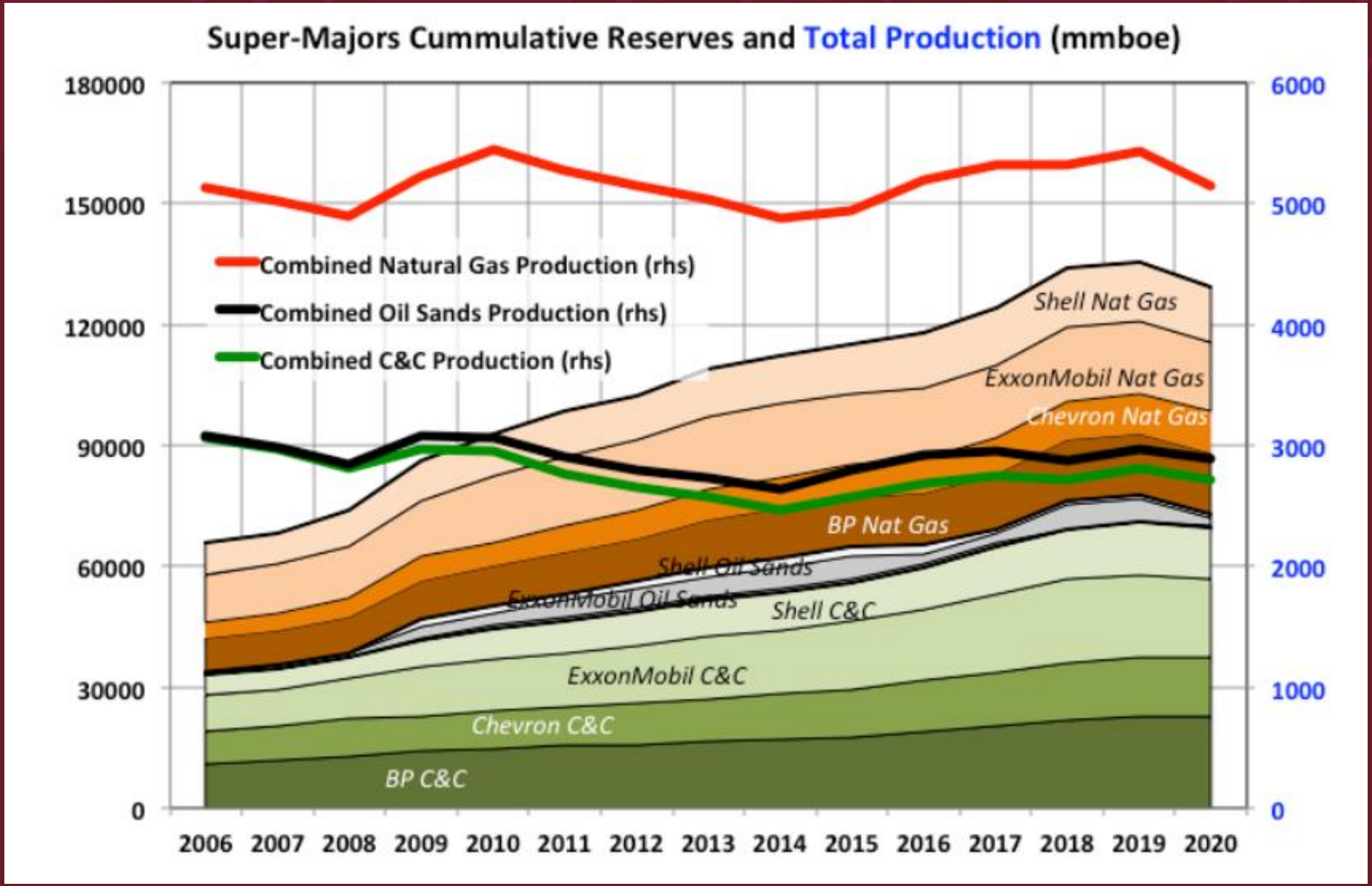
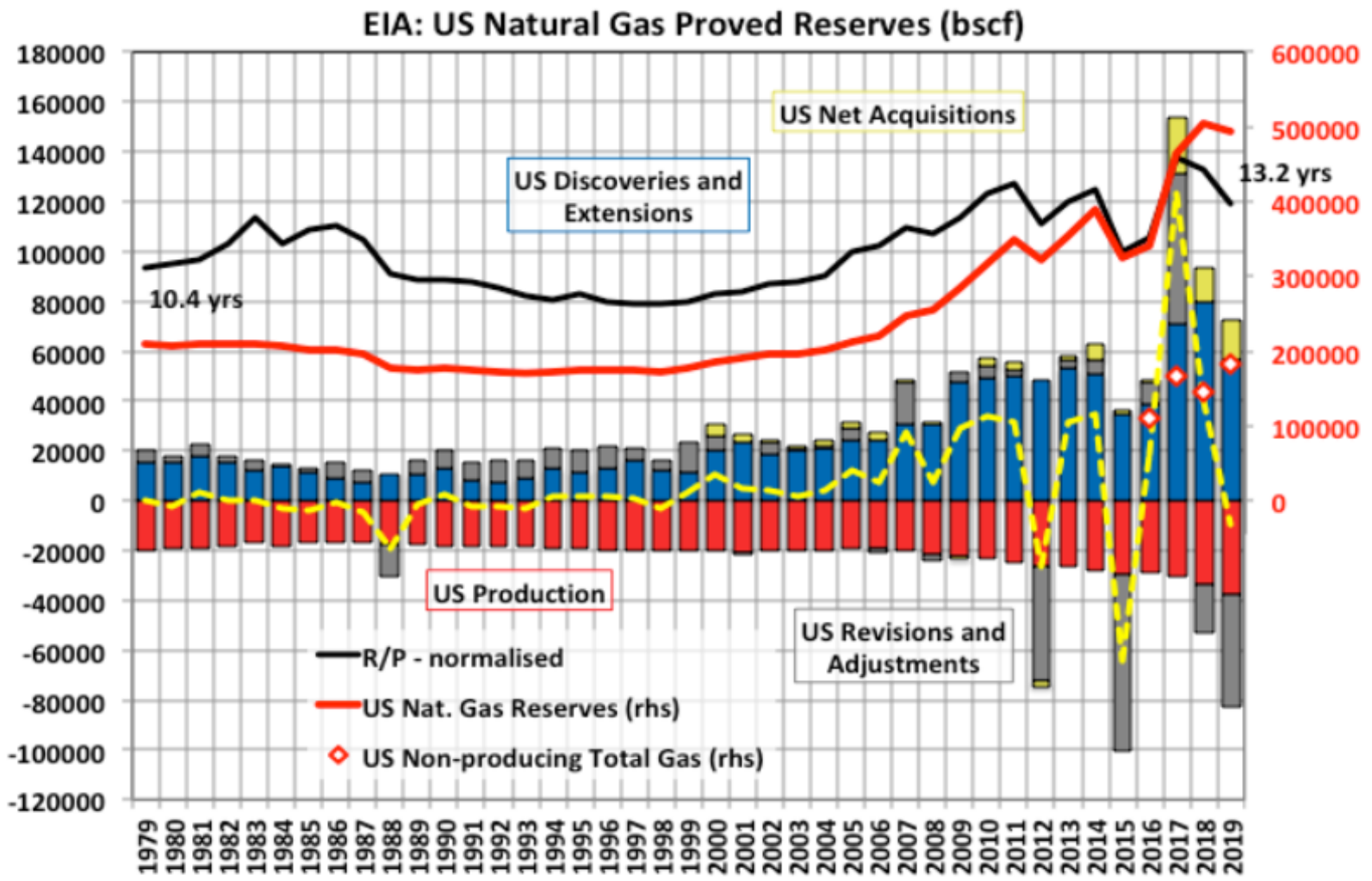


Figure 7. Tight oil companies spend 4 times more than they earn. Source: Google Finance and Labyrinth Consulting Services, Inc.





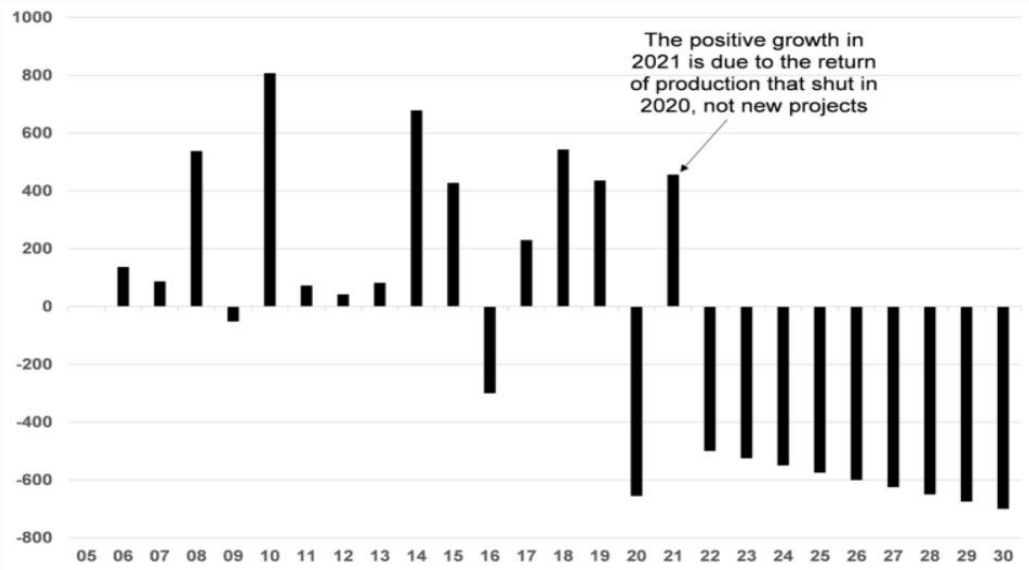
Source: http://peakoilbarrel.com/annual-reserve-changes-part-i-eia-and-super-majors/#more-30934



The R/P (reserves over production) values have been normalized to fit on the left hand scale. Oil was at a maximum in 2013 and natural gas in 2018. Both are have been declining quickly in recent years, which implies production has been maintained at higher levels than the reserve base, however fast it has grown, can support over the long term.

Exhibit 10: Non-OPEC ex US shale production is expected to decline in the coming years

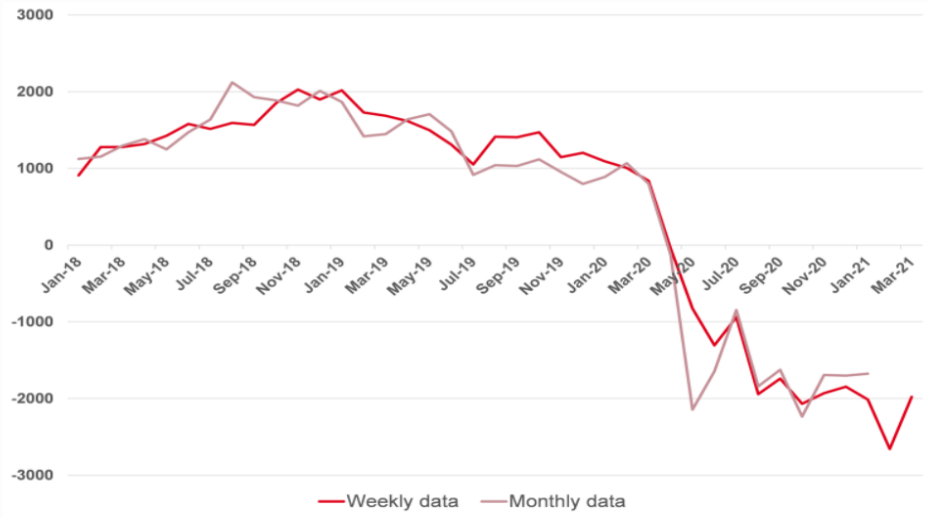
Kb/d year-over-year



Source: Goldmoney Research

Exhibit 11: US production has yet to show any meaningful recovery despite the full price recovery

Kb/d year-over-year



Source: EIA. Goldmoney Research

Crude Oil vs Natural Gas - 10 Year Daily Chart

This interactive chart compares the price performance of West Texas Intermediate (WTI) or Nymex Crude Oil vs the Henry Hub Natural Gas spot price.

Canadian Legislated to be Added Carbon Levy per GJ of Natural Gas:

2021 - $2.02/GJ

2026 - $5.57/GJ

2030 - $8.60/GJ

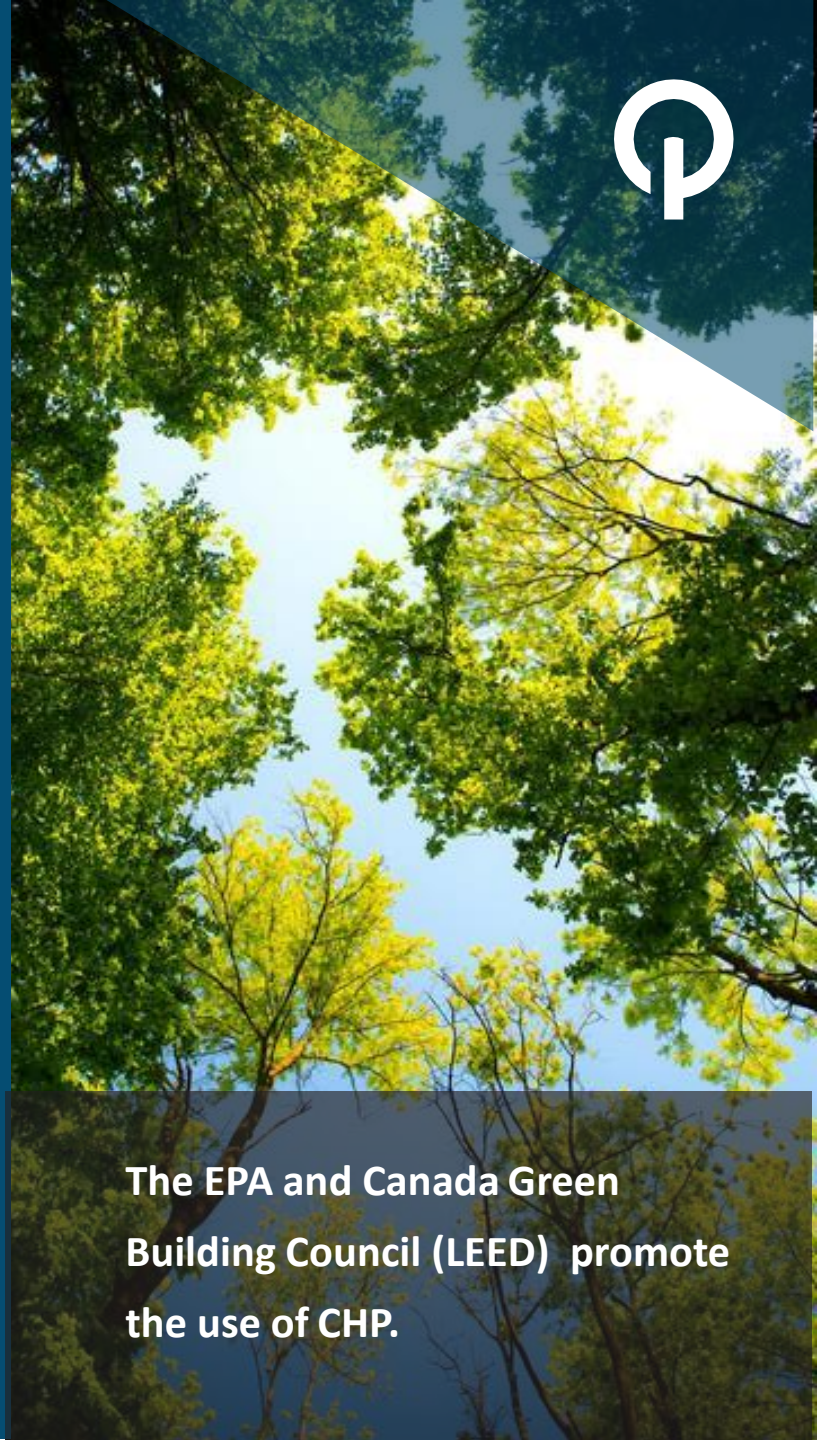
CHP IS A SUSTAINABLE SOLUTION

EFFICIENCY

- CHP avoids heat and transmission losses, so is far more efficient than the electric grid.
- Conventional electricity and heat production is only 56% efficient, while CHP generation can reach 80-90% system efficiency.

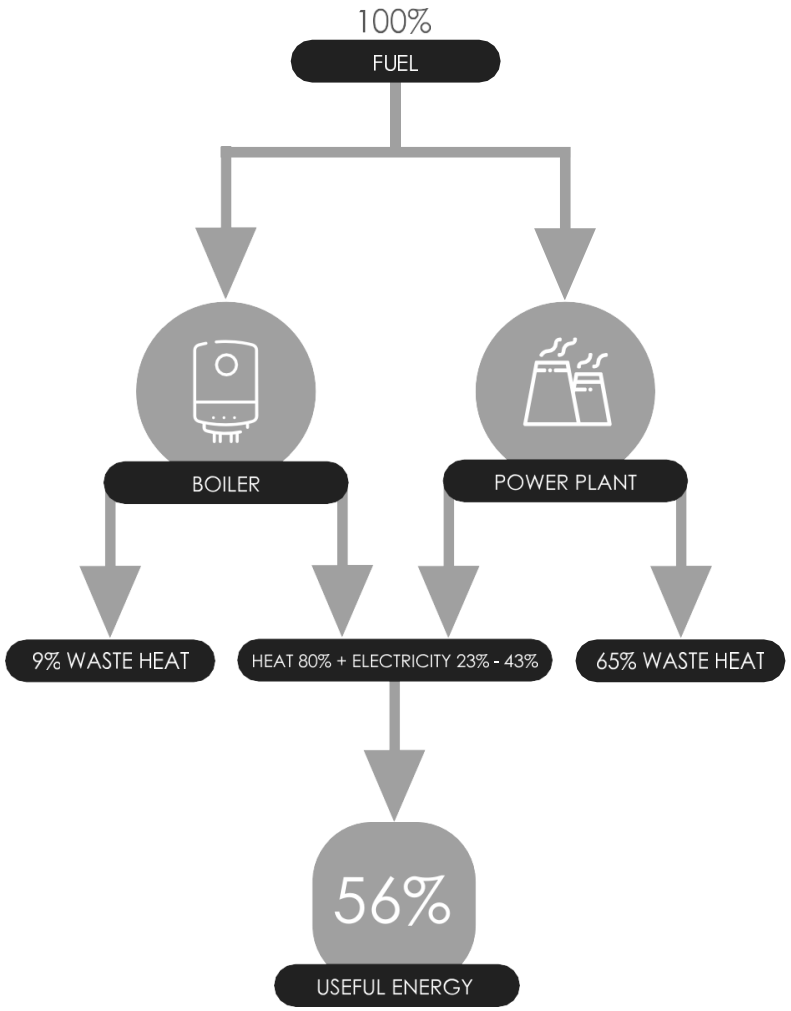
ENVIRONMENTAL

- More efficient energy production reduces air pollution and greenhouse gas emissions.
- By recovering ‘waste heat,’ CHP systems reduce carbon emissions by 15-40% vs. the grid. EPA statistics show a 5MW natural gas CHP system can decrease emissions from 45 kT/yr to 23 kT/yr.

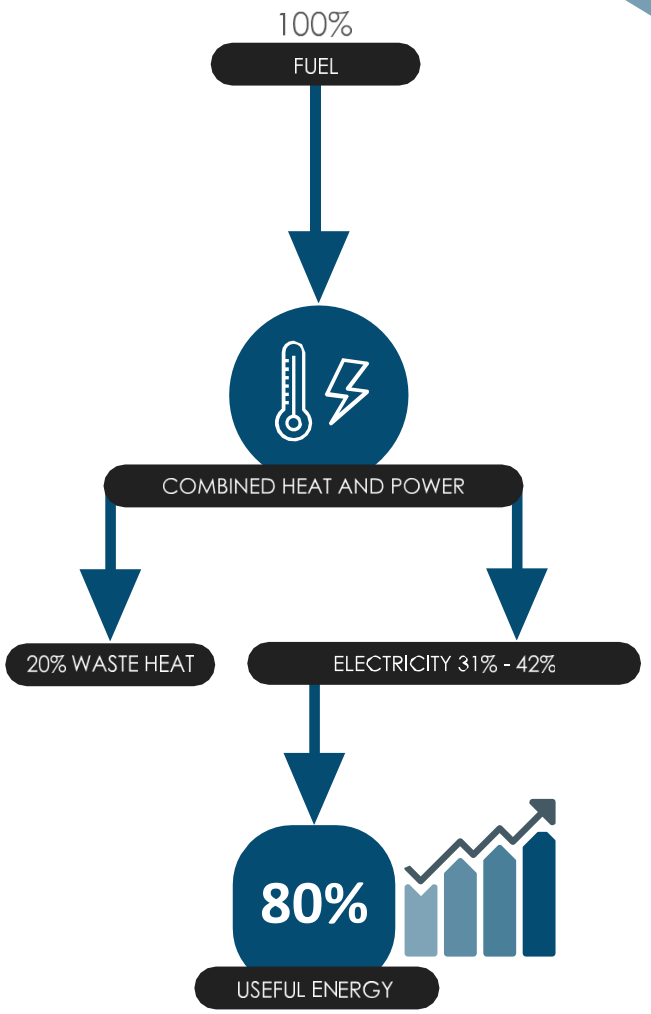


The EPA and Canada Green Building Council (LEED) promote the use of CHP.

CONVENTIONAL POWER GENERATION



COMBINED HEAT AND POWER

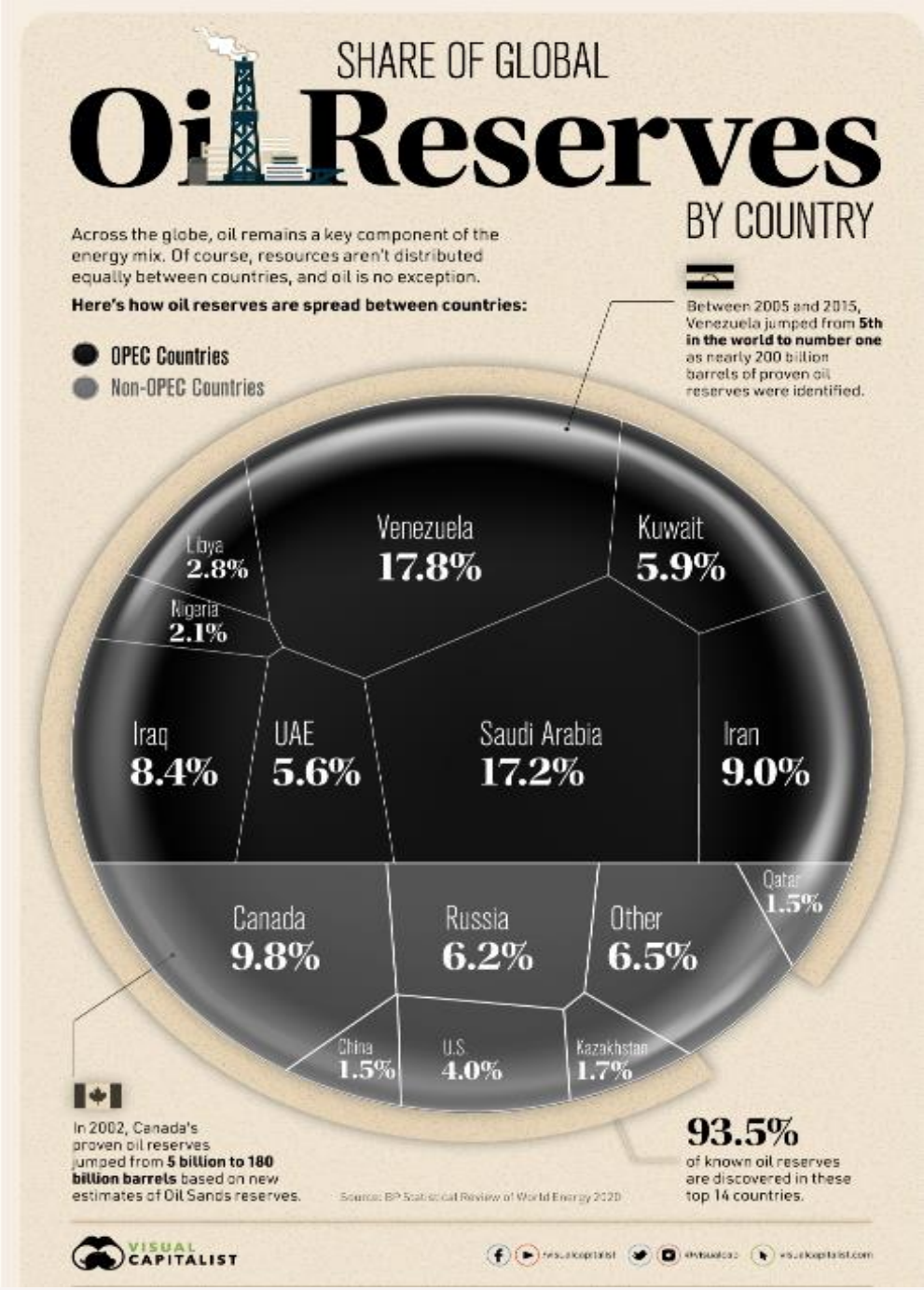


CONTACT

DAN CLOUTIER

General Manager
dan@onsitepowerpartners.com
403.703.7611

Oil


SHARE OF GLOBAL
Oil Reserves
BY COUNTRY
Across the globe, oil remains a key component of the energy mix. Of course, resources aren't distributed equally between countries, and oil is no exception.
Here's how oil reserves are spread between countries:
OPEC Countries
Non-OPEC Countries
Between 2005 and 2015, Venezuela jumped from 5th in the world to number one as nearly 200 billion barrels of proven oil reserves were identified.
Venezuela 17.8%
Kuwait 5.9%
Libya 2.8%
Nigeria 2.1%
Iraq 8.4%
UAE 5.6%
Saudi Arabia 17.2%
Iran 9.0%
Qatar 1.5%
Canada 9.8%
Russia 6.2%
Other 6.5%
China 1.5%
U.S 4.0%
Kazakhstan 1.7%
In 2002, Canada's proven oil reserves jumped from 5 billion to 180 billion barrels based on new estimates of Oil Sands reserves.
93.5%
of known oil reserves are discovered in these top 14 countries.
VISUAL CAPITALIST

THE PRODUCTS DERIVED FROM

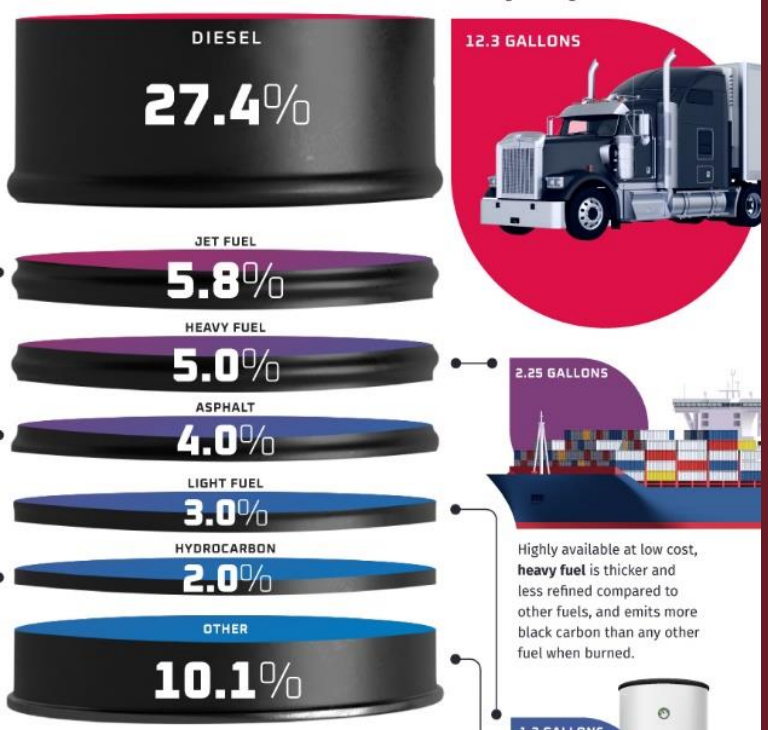
A BARREL OF CRUDE OIL

A barrel of crude oil (42 gallons) produces just under 45 gallons of refined products, from transportation fuels to essential materials for everyday products.

This graphic uses a barrel of oil to represent the proportions of how the majority of crude oil is processed.

The primary product of crude oil, **finished motor gasoline** is made from a blend of crude oil and petroleum liquids.

Most heavyweight trucks and industrial vehicles use **diesel fuel,** and diesel engine generators are used as a backup power supply for large buildings.



Both **kerosene-jet fuel** and **naphtha-type jet fuel** are used in jet aircraft engines.

Highly available at low cost, **heavy fuel** is thicker and less refined compared to other fuels, and emits more black carbon than any other fuel when burned.

Asphalt binds the stone, sand, and gravel that make up the sidewalks and roads of our cities. It's also used in waterproofing, sealing, and insulation products.

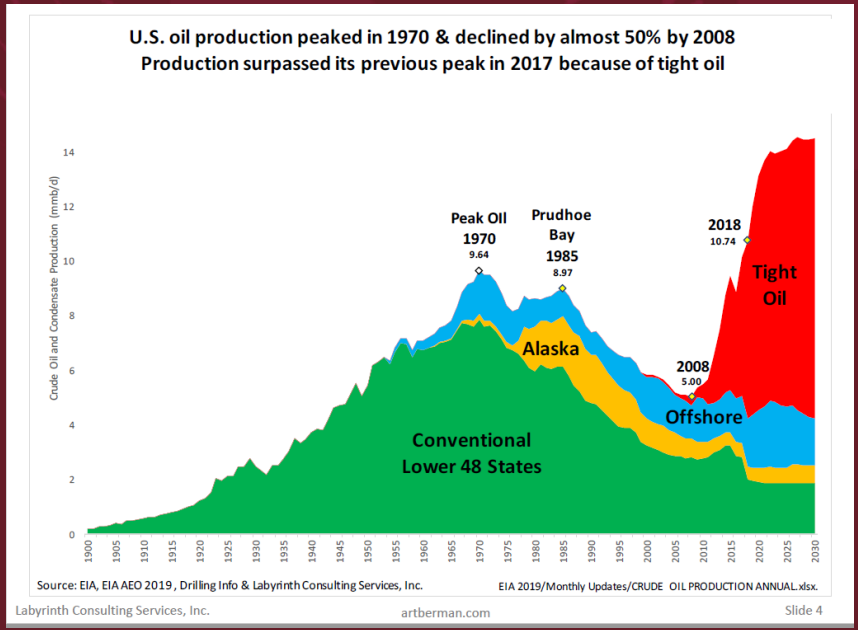
Light fuel oil is used in liquid-fuel burning equipment to produce heat in domestic and small commercial spaces.

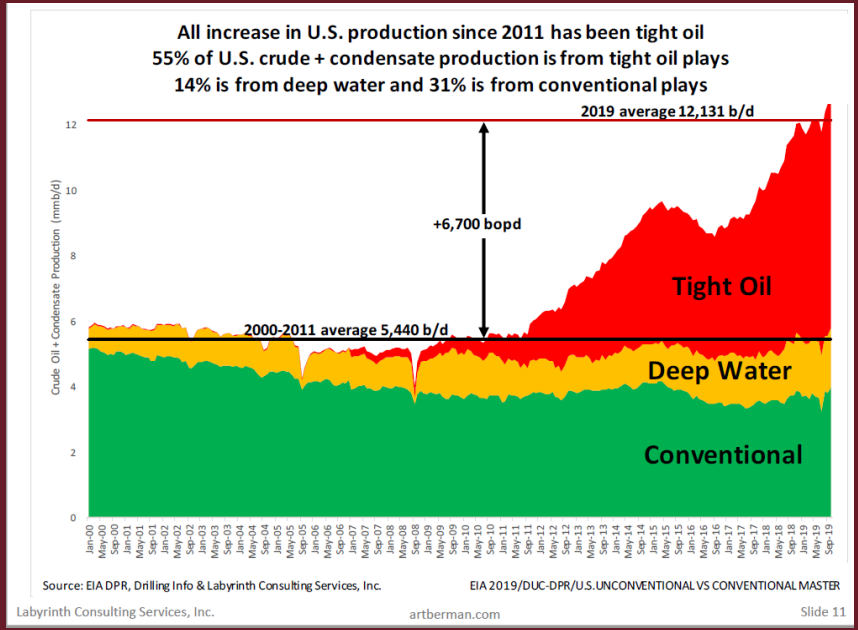
Hydrocarbon gas liquids like propane and butane power vital utilities like water heating systems to stovetops.

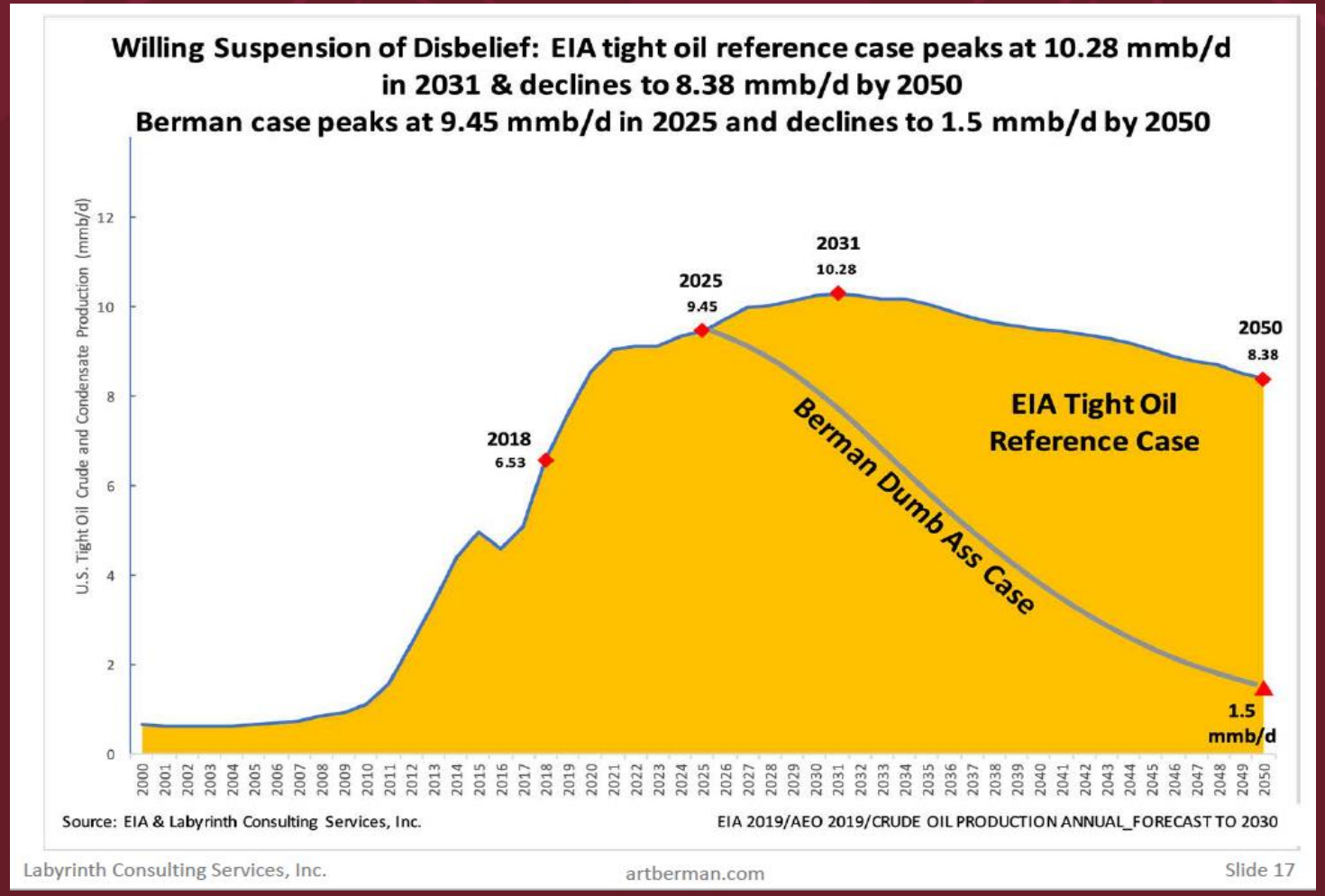
HGLs are also part of everyday items and materials like plastics, synthetic rubber, and paints and solvents.

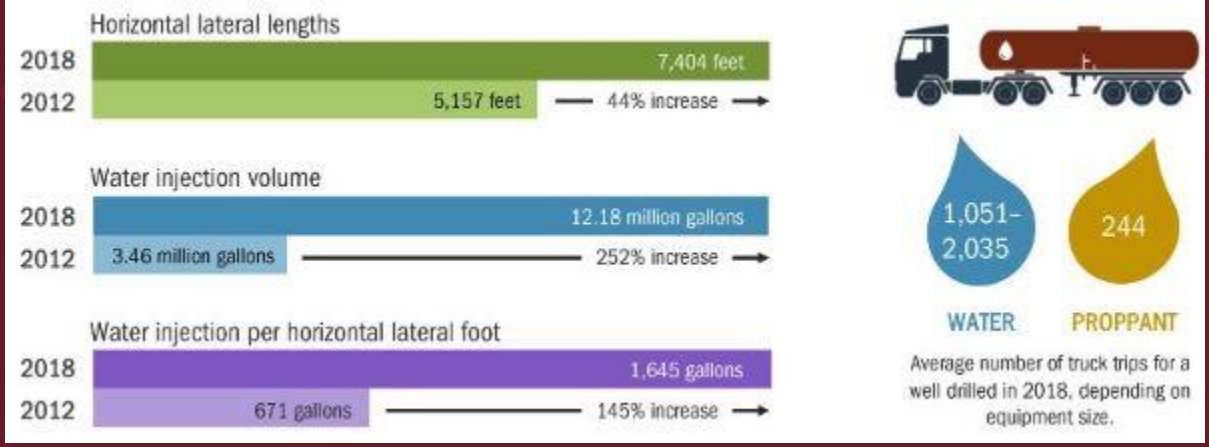
Residual fuels, petrochemical feedstocks, and other miscellaneous petroleum products are blended with other fuels to create finished fuel products. They're also part of essential materials like wax and plastics used in everyday items.

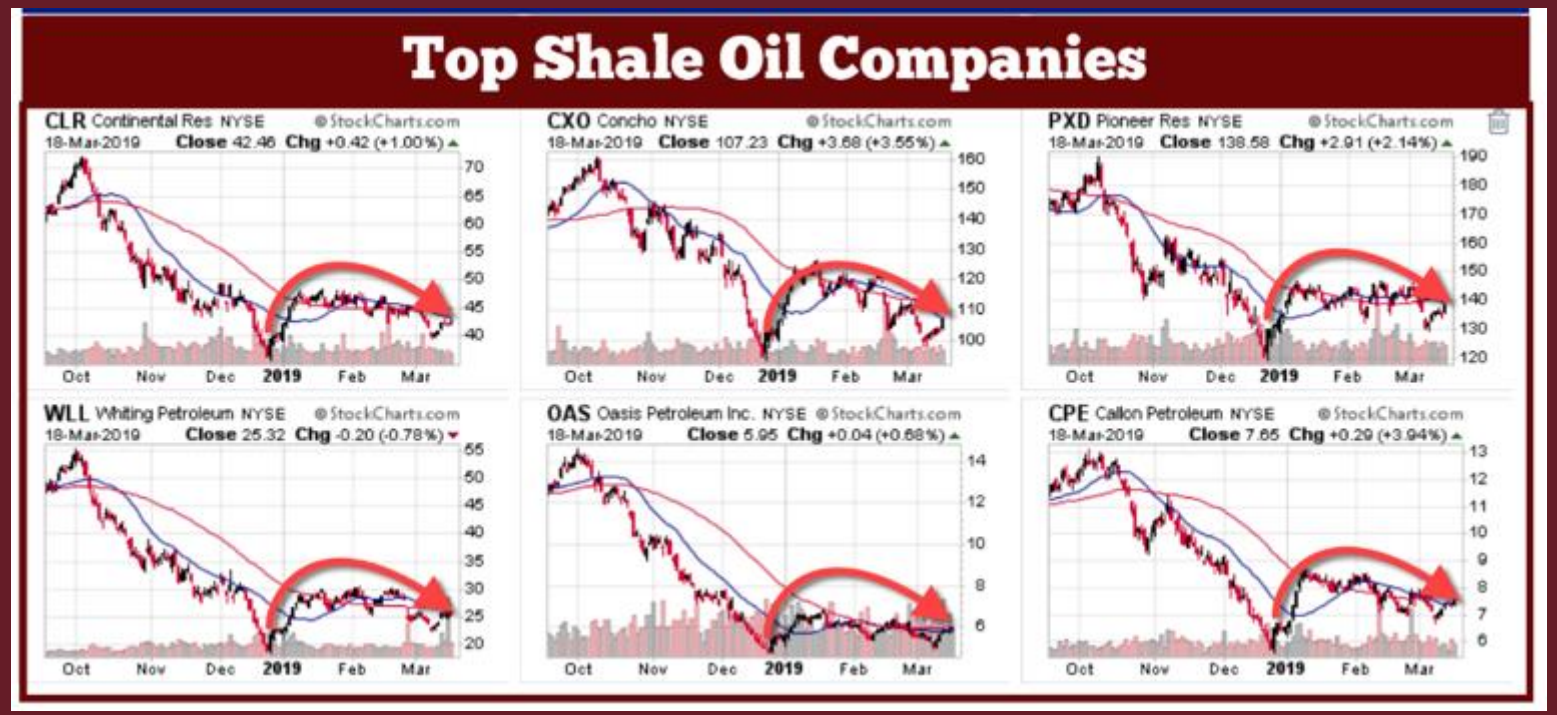
Source: Canadian Association of Petroleum Producers (CAPP)

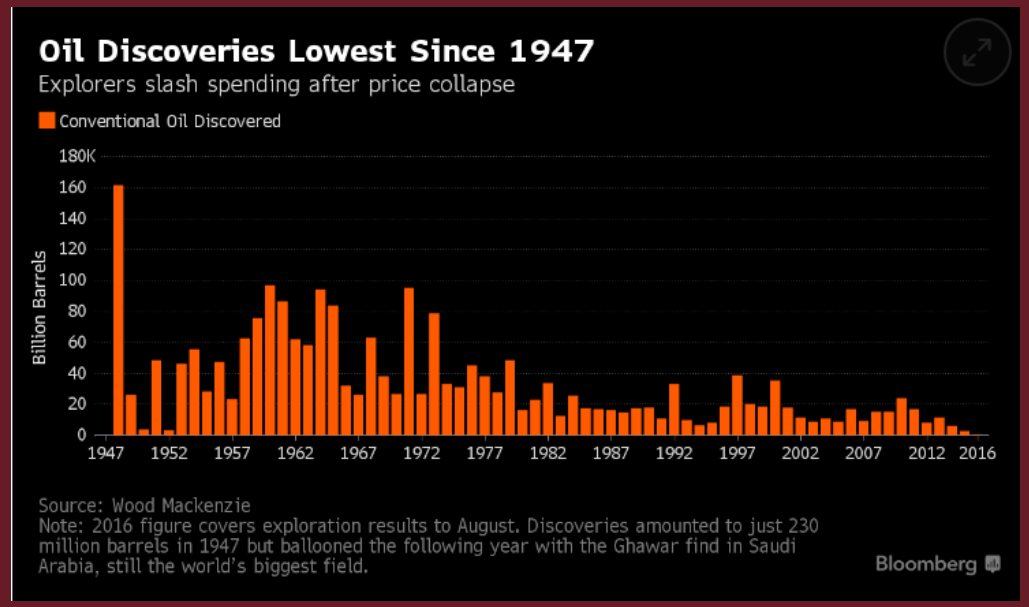

U.S. oil production peaked in 1970 & declined by almost 50% by 2008
Production surpassed its previous peak in 2017 because of tight oil
Crude Oil and Condensate Production (mmb/d)
Peak Oil
1970
9.64
Prudhoe
Bay
1985
8.97
2018
10.74
Tight
Oil
Alaska
2008
5.00
Offshore
Conventional
Lower 48 States
Source: EIA, EIA AEO 2019 , Drilling Info & Labyrinth Consulting Services, Inc.
EIA 2019/Monthly Updates/CRUDE OIL PRODUCTION ANNUAL.xlsx.
Labyrinth Consulting Services, Inc.
artberman.com
Slide 4

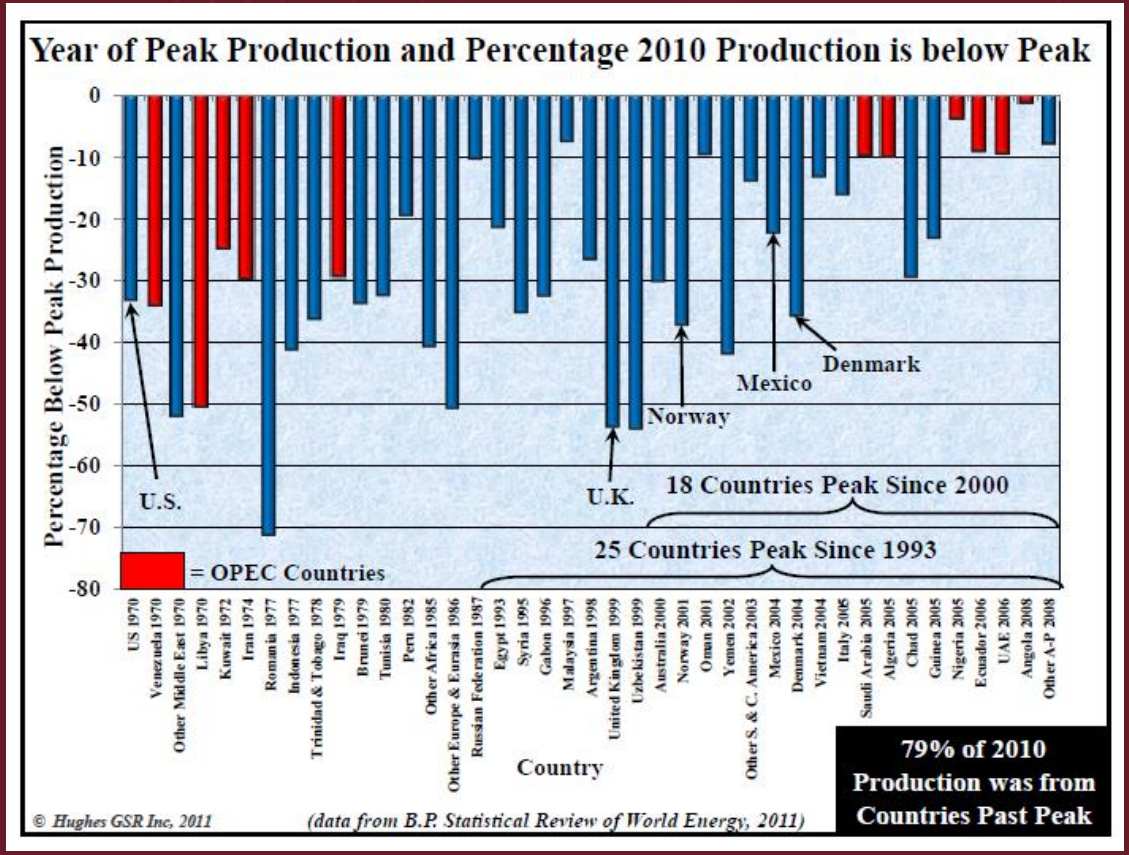

All increase in U.S. production since 2011 has been tight oil
55% of U.S. crude + condensate production is from tight oil plays
14% is from deep water and 31% is from conventional plays
2019 average 12,131 b/d
+6,700 bopd
2000-2011 average 5,440 b/d
Crude Oil + Condensate Production (mmb/d)
Tight Oil
Deep Water
Conventional
Source: EIA DPR, Drilling Info & Labyrinth Consulting Services, Inc.
EIA 2019/DUC-DPR/U.S.UNCONVENTIONAL VS CONVENTIONAL MASTER
Labyrinth Consulting Services, Inc.
artberman.com
Slide 11

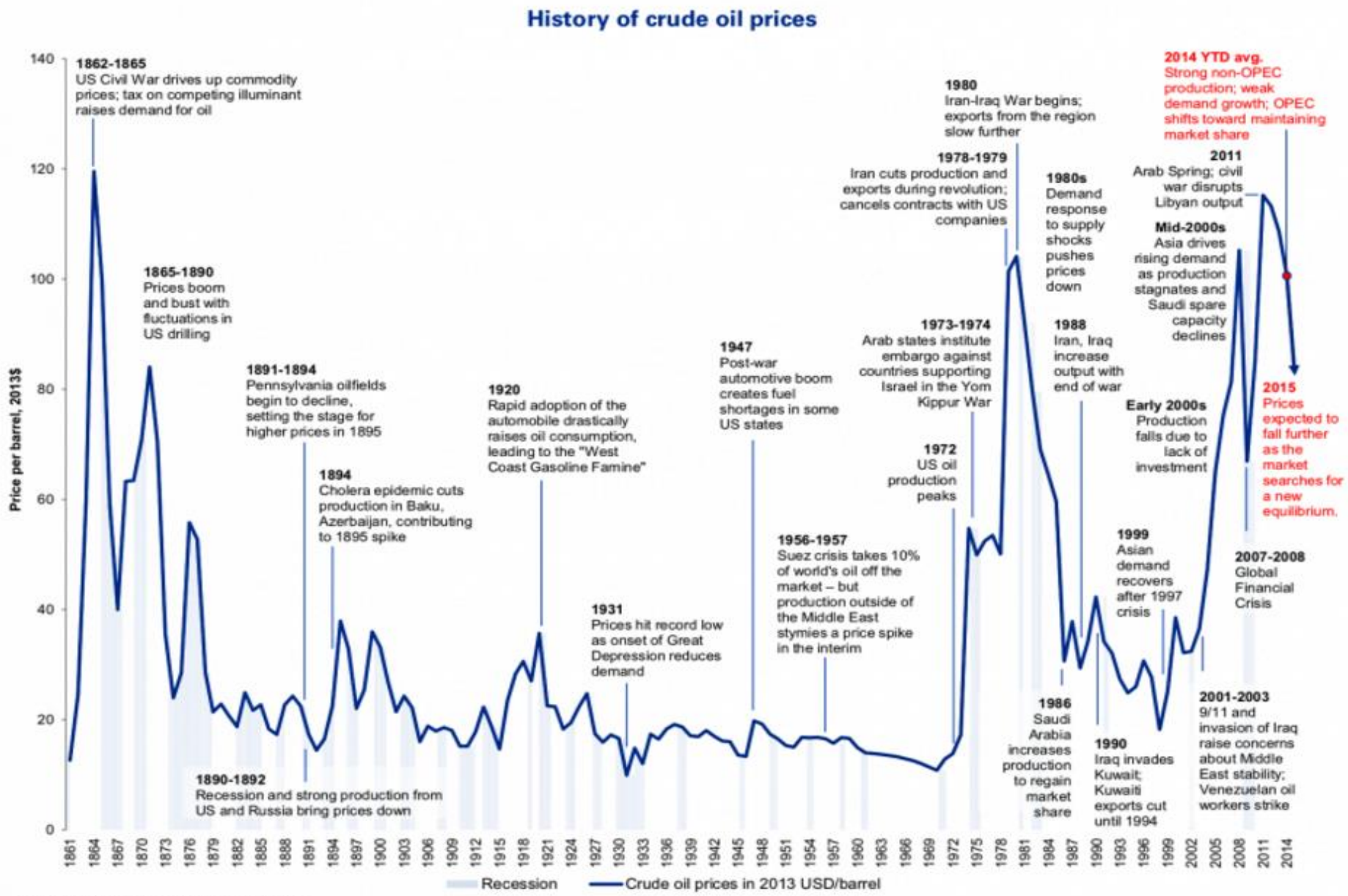

Willing Suspension of Disbelief: EIA tight oil reference case peaks at 10.28 mmb/d
in 2031 & declines to 8.38 mmb/d by 2050
Berman case peaks at 9.45 mmb/d in 2025 and declines to 1.5 mmb/d by 2050
U.S. Tight Oil Crude and Condensate Production (mmb/d)
2018
6.53
2025
9.45
2031
10.28
2050
8.38
1.5
mmb/d
Berman Dumb Ass Case
EIA Tight Oil
Reference Case
Source: EIA & Labyrinth Consulting Services, Inc.
EIA 2019/AEO 2019/CRUDE OIL PRODUCTION ANNUAL_FORECAST TO 2030
Labyrinth Consulting Services, Inc.
artberman.com
Slide 17


Horizontal lateral lengths
2018
7,404 feet
2012
5,157 feet
44% increase
Water injection volume
2018
12.18 million gallons
2012
3.46 million gallons
252% increase
Water injection per horizontal lateral foot
2018
1,645 gallons
2012
671 gallons
145% increase
1,051–2,035
244
WATER
PROPPANT
Average number of truck trips for a well drilled in 2018, depending on equipment size.

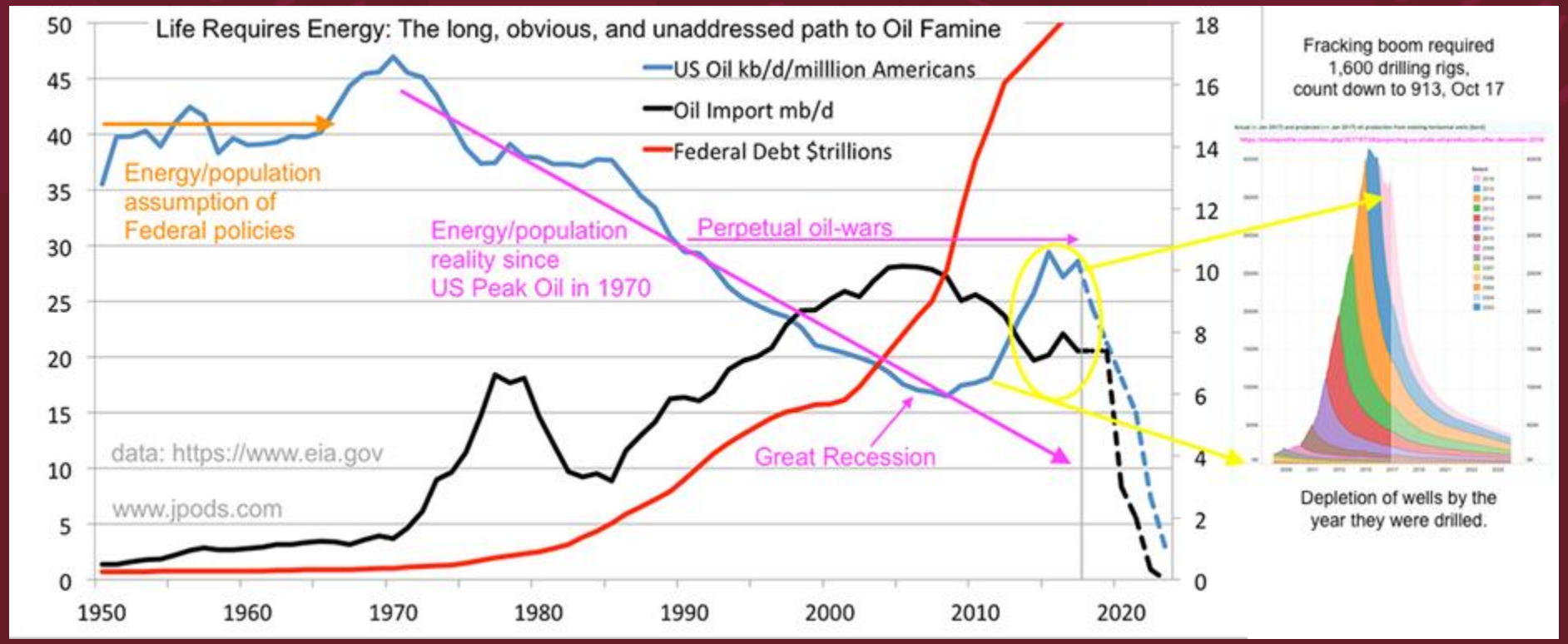

Top Shale Oil Companies
CLR Continental Res NYSE
18-Mar-2019 Close 42.46 Chg +0.42 (+1.00%)
CXO Concho NYSE
18-Mar-2019 Close 107.23 Chg +3.68 (+3.55%)
PXD Pioneer Res NYSE
18-Mar-2019 Close 138.58 Chg +2.91 (+2.14%)
WLL Whiting Petroleum NYSE
18-Mar-2019 Close 25.32 Chg -0.20 (-0.78%)
OAS Oasis Petroleum Inc. NYSE
18-Mar-2019 Close 5.95 Chg +0.04 (+0.68%)
CPE Callon Petroleum NYSE
18-Mar-2019 Close 7.65 Chg +0.29 (+3.94%)
Oct Nov Dec 2019 Feb Mar

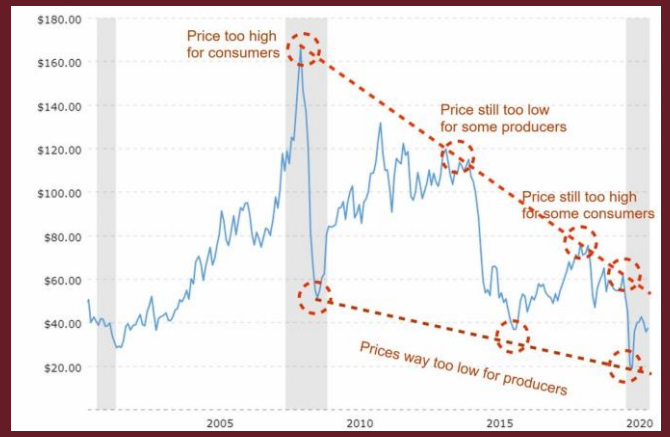

Oil Discoveries Lowest Since 1947
Explorers slash spending after price collapse
Conventional Oil Discovered
Billion Barrels
180K
160
140
120
100
80
60
40
20
0
1947
1952
1957
1962
1967
1972
1977
1982
1987
1992
1997
2002
2007
2012
2016
Source: Wood Mackenzie
Note: 2016 figure covers exploration results to August. Discoveries amounted to just 230 million barrels in 1947 but ballooned the following year with the Ghawar find in Saudi Arabia, still the world's biggest field.
Bloomberg


Year of Peak Production and Percentage 2010 Production is below Peak
Percentage Below Peak Production
0
-10
-20
-30
-40
-50
-60
-70
-80
U.S.
U.K.
Norway
Mexico
Denmark
18 Countries Peak Since 2000
25 Countries Peak Since 1993
= OPEC Countries
US 1970
Venezuela 1970
Other Middle East 1970
Libya 1970
Kuwait 1972
Iran 1974
Romania 1977
Indonesia 1977
Trinidad & Tobago 1978
Iraq 1979
Brunei 1979
Tunisia 1980
Peru 1982
Other Africa 1985
Other Europe & Eurasia 1986
Russian Federation 1987
Egypt 1993
Syria 1995
Gabon 1996
Malaysia 1997
Argentina 1998
United Kingdom 1999
Uzbekistan 1999
Australia 2000
Norway 2001
Oman 2001
Yemen 2002
Other S. & C. America 2003
Mexico 2004
Denmark 2004
Vietnam 2004
Italy 2005
Saudi Arabia 2005
Algeria 2005
Chad 2005
Guinea 2005
Nigeria 2005
Ecuador 2006
UAE 2006
Angola 2008
Other A-P 2008
Country
© Hughes GSR Inc, 2011
(data from B.P. Statistical Review of World Energy, 2011)
79% of 2010 Production was from Countries Past Peak



Note: 2014 YTD average price is as of December 8, 2014.
Source for data: BP, NBER/Federal Reserve Bank of St. Louis.
Source for annotations: Hamilton, James, "Historical Oil Shocks," University of California, San Diego; various news sources; Goldman Sachs Global Investment Research.


Life Requires Energy: The long, obvious, and unaddressed path to Oil Famine
US Oil kb/d/milllion Americans
Oil Import mb/d
Federal Debt $trillions
Energy/population assumption of Federal policies
Energy/population reality since US Peak Oil in 1970
Perpetual oil-wars
Great Recession
data: https://www.eia.gov
www.jpods.com
Fracking boom required 1,600 drilling rigs, count down to 913, Oct 17
Depletion of wells by the year they were drilled.
50
45
40
35
30
25
20
15
10
5
0
18
16
14
12
10
8
6
4
2
0
1950
1960
1970
1980
1990
2000
2010
2020

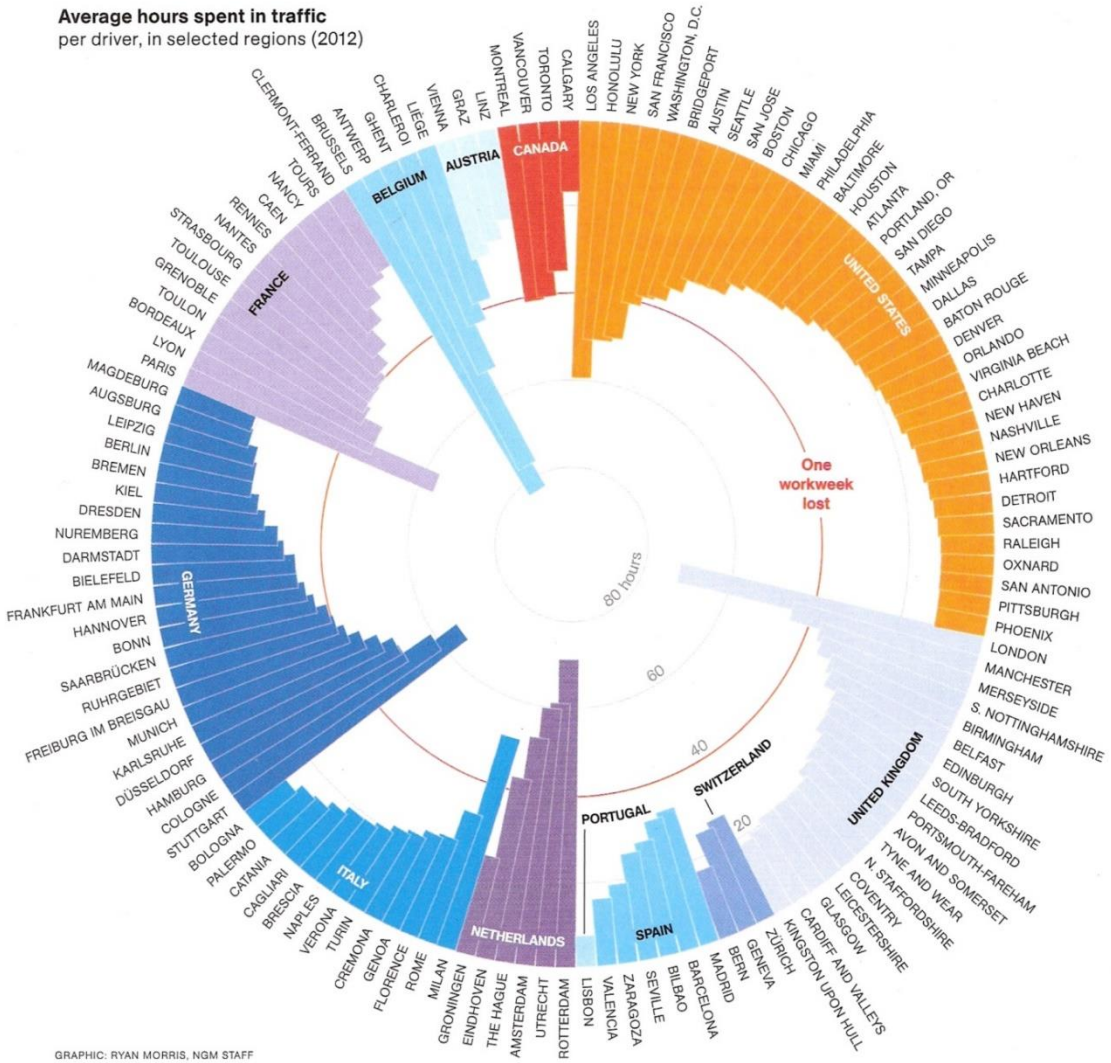

Price too high for consumers
Price still too low for some producers
Price still too high for some consumers
Prices way too low for producers
$180.00
$160.00
$140.00
$120.00
$100.00
$80.00
$60.00
$40.00
$20.00
2005
2010
2015
2020

Commuter Science

By 8 a.m., rush hour is at full throttle in most cities. Accidents, the cost of fuel, and the quality of public transportation aren't the only factors that can make the drive to work range from ho-hum to hellish. According to traffic analyst Jim Bak, there's another thing that can cause commuting lengths to fluctuate: the state of the economy.

"When the recession hit in 2008, congestion across the U.S. dropped 30 percent," he says. Four years later, in 2012, drivers in Italy, France, and Spain also spent less time on the road as unemployment, especially among youth, skyrocketed in the wake of Europe's debt crisis. That same year, European Union officials tasked with managing the problem flocked to Brussels, Belgium—causing traffic and commute times in that city to soar. *—Catherine Zuckerman*

Average hours spent in traffic
per driver, in selected regions (2012)

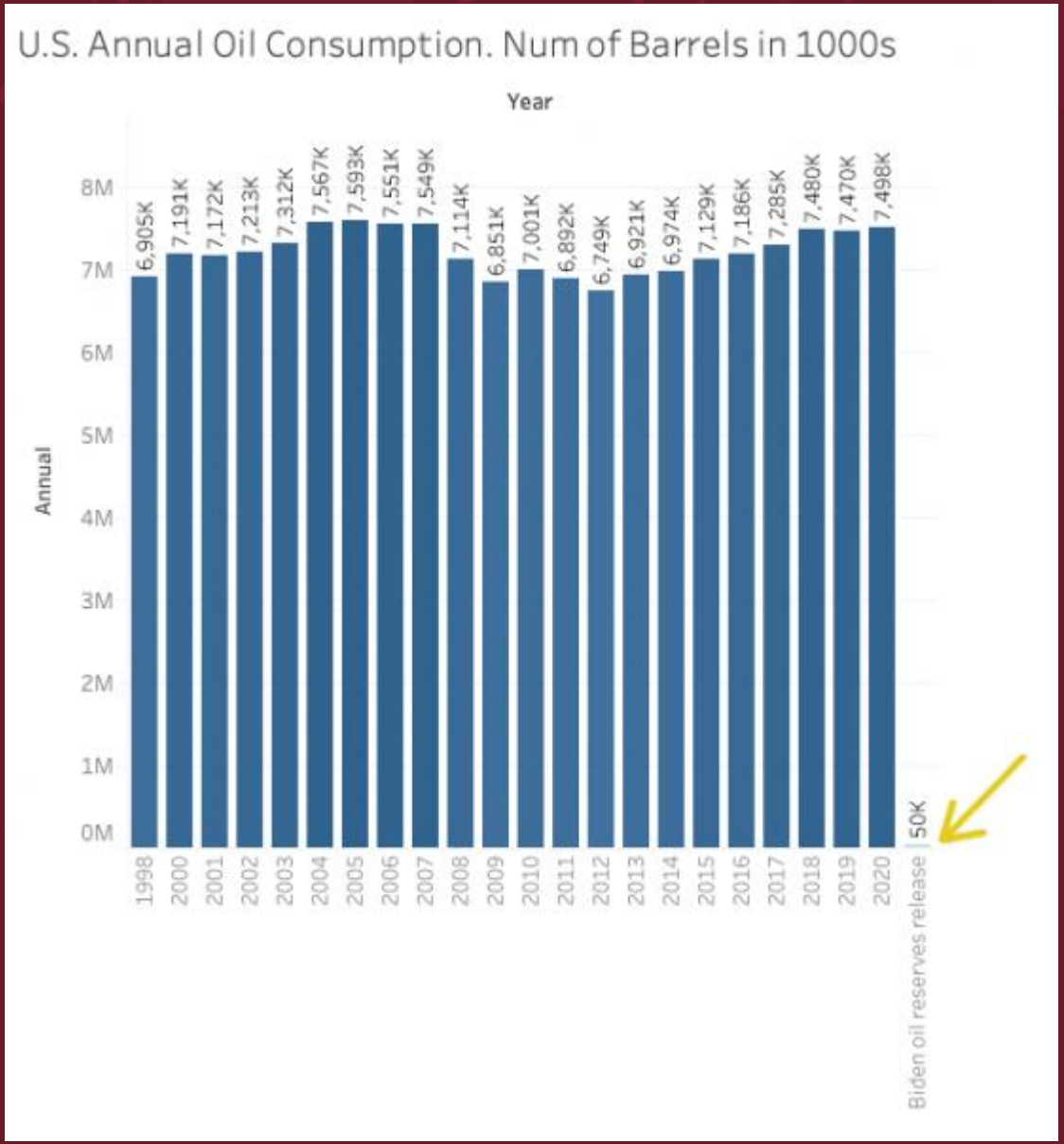


GRAPHIC: RYAN MORRIS, NGM STAFF
SOURCE: INRIX

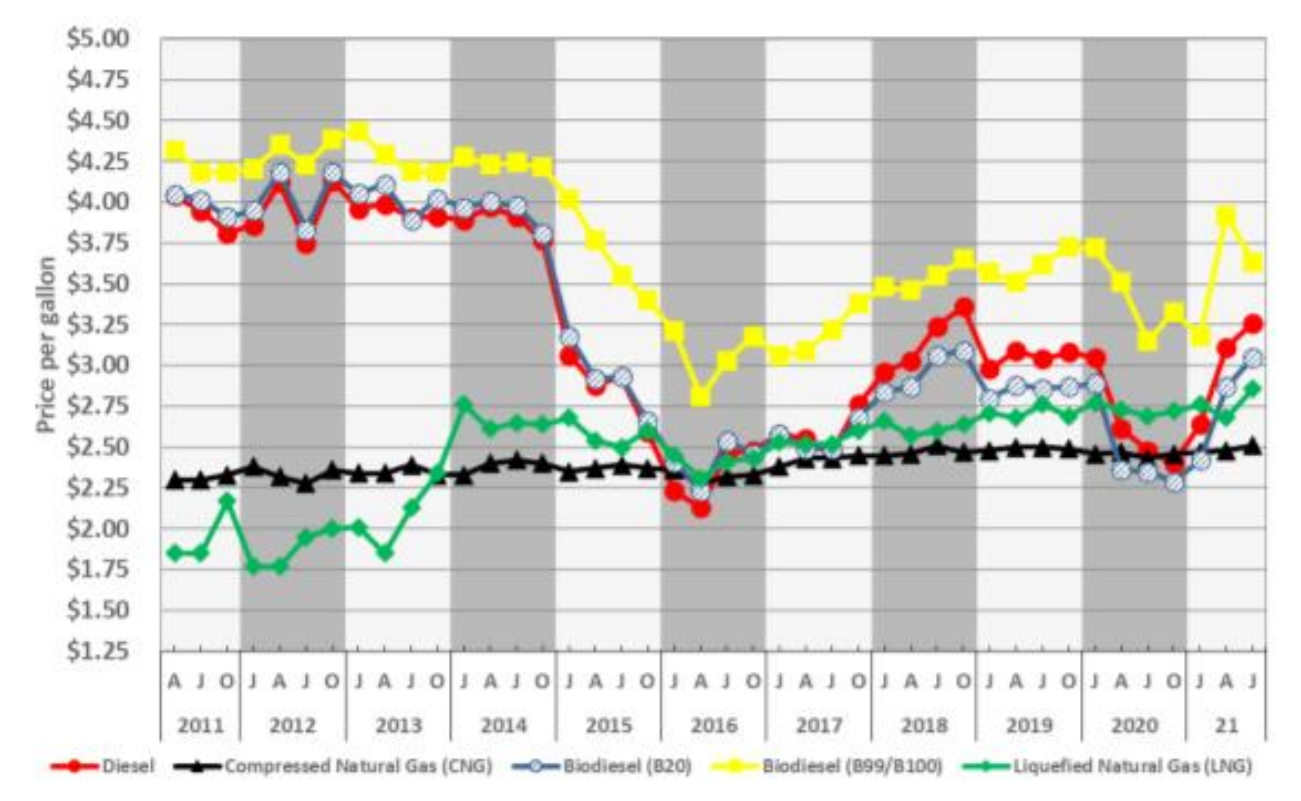
If you earn $100 and pay $33 income tax you're left with $67.

You then buy $67 worth of fuel and in doing so pay a 48% fuel tax (fuel tax = $32.16 + $6.70 GST).

This means that the government just got $71.86 tax from your hard earned $100.

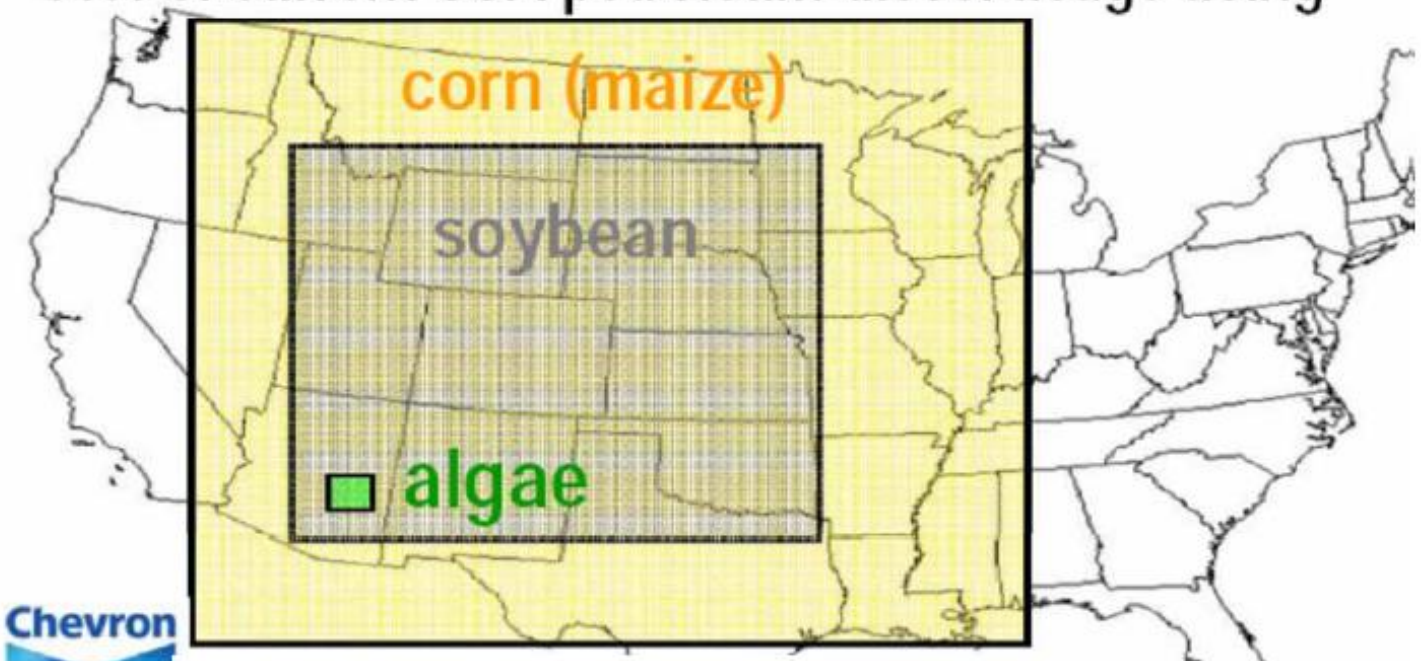

U.S. Annual Oil Consumption. Num of Barrels in 1000s
Year
Annual
8M
7M
6M
5M
4M
3M
2M
1M
0M
6,905K
7,191K
7,172K
7,213K
7,312K
7,567K
7,593K
7,551K
7,549K
7,114K
6,851K
7,001K
6,892K
6,749K
6,921K
6,974K
7,129K
7,186K
7,285K
7,480K
7,470K
7,498K
1998
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
Biden oil reserves release
50K

Transport fuel comparisons



Source: https://afdc.energy.gov/files/u/publication/alternative_fuel_price_report_july_2021.pdf

WHY THE INTEREST IN MICROALGAE BIOFUELS?
Thought to have extraordinary productivity potential.
Example of projection: land area required to replace 50% of current USA petroleum-diesel usage using



Chevron

Projected ~80,000 liters oil/hectare-year Chevron 2008

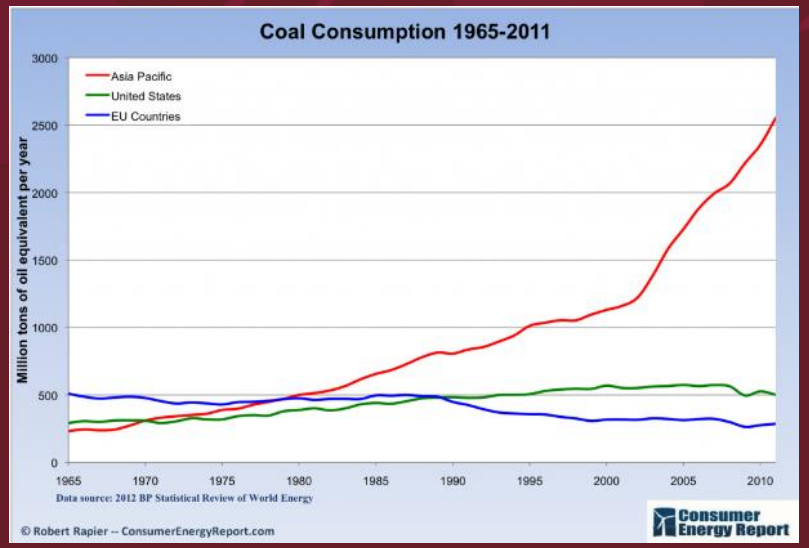
ARK
Agro Resilience Kit Ltd.

www.arkltd.net

Algae Greenhouses

Coal

Led by the USGS, many others including the EIA the SEC, and even the coal companies themselves are finally starting to come to terms with the fact that a huge chunk of what we've been calling coal *reserves* are actually economically unattractive *resources* which are unlikely to be extracted, given the downward price pressures and production cost increases coal is subject to. In this vein, Arch Coal now says that their Black Thunder mine — the US's single most productive coal mine, once responsible for about 10% of all US coal — is likely to start playing out by 2020. (Arch Coal Inc 2013 10-K, page 15). There are potential leasing tracts nearby, but with operating margins of just $0.28 per ton in the Powder River Basin, and company-wide losses of more than half a billion dollars a year, will the company really be able to commit the capital required to develop them?


Coal Consumption 1965-2011
Asia Pacific
United States
EU Countries
Million tons of oil equivalent per year
3000
2500
2000
1500
1000
500
0
1965
1970
1975
1980
1985
1990
1995
2000
2005
2010
Data source: 2012 BP Statistical Review of World Energy
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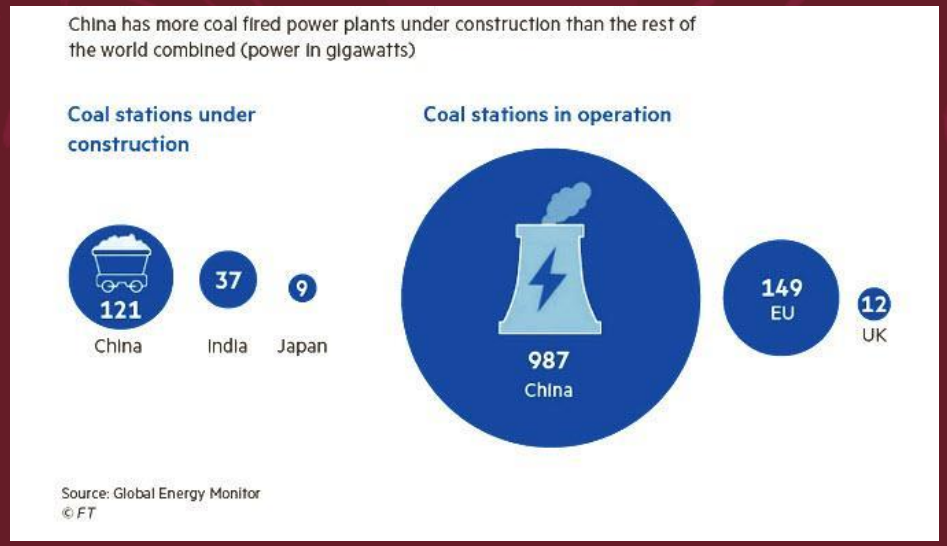
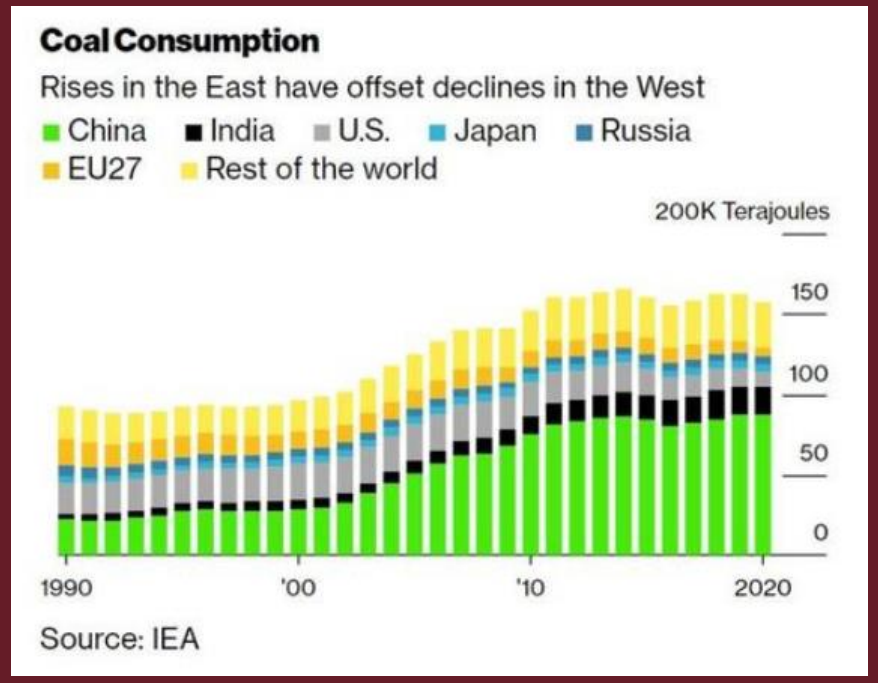
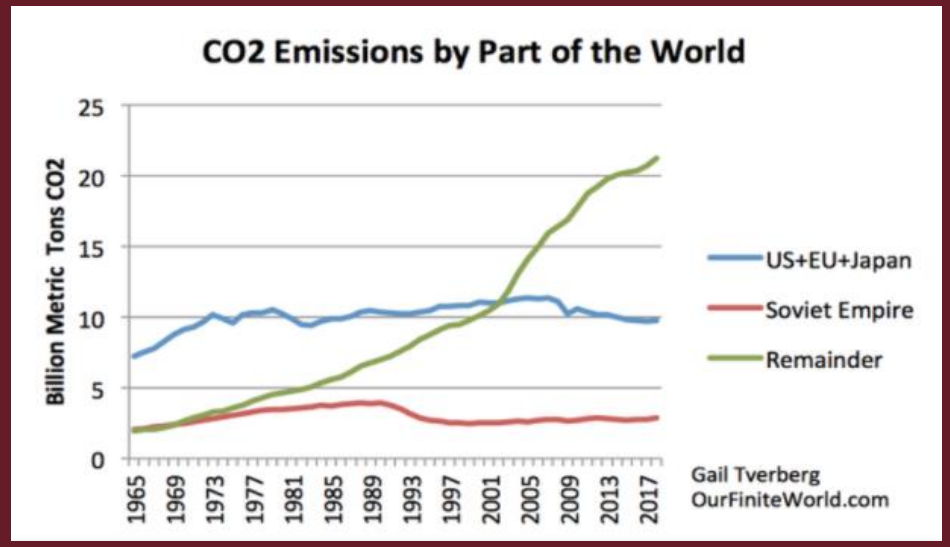
Consumer Energy Report


China has more coal fired power plants under construction than the rest of the world combined (power in gigawatts)
Coal stations under construction
121
China
37
India
9
Japan
Coal stations in operation
987
China
149
EU
12
UK
Source: Global Energy Monitor
© FT


Coal Consumption
Rises in the East have offset declines in the West
China
India
U.S.
Japan
Russia
EU27
Rest of the world
200K Terajoules
150
100
50
0
1990
'00
'10
2020
Source: IEA


CO2 Emissions by Part of the World
Billion Metric Tons CO2
25
20
15
10
5
0
1965
1969
1973
1977
1981
1985
1989
1993
1997
2001
2005
2009
2013
2017
US+EU+Japan
Soviet Empire
Remainder
Gail Tverberg
OurFiniteWorld.com

Coal making a global comeback in 2021

https://www.reuters.com/business/energy/worldwide-energy-shortage-shows-up-surging-coal-gas-oil-prices-kemp-2021-09-24/?taid=614e1b8488b4be000154f6ae&utm_campaign=trueAnthem:+Trending+Content&utm_medium=trueAnthem&utm_source=twitter

UK fires up coal power plant as gas prices soar

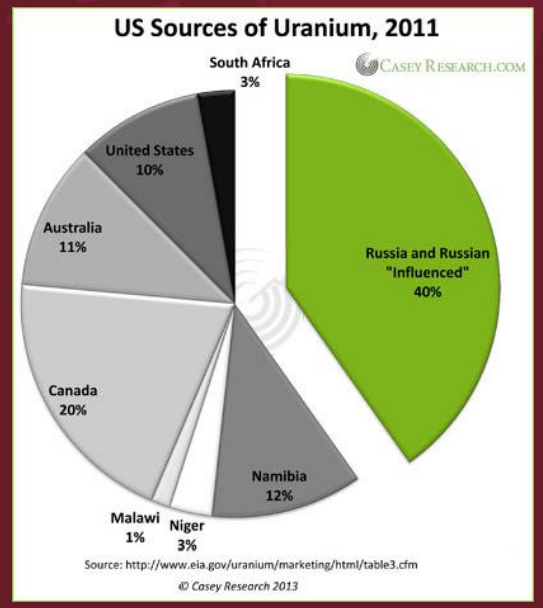
While Democrats Try To 'Kill Coal' In US, Asia Heads In The Opposite Direction

https://www.zerohedge.com/commodities/chinese-coal-prices-soar-record-high-ahead-surge-coal-production

https://www.zerohedge.com/commodities/us-coal-miners-all-sold-out-coal-2022

Nuclear

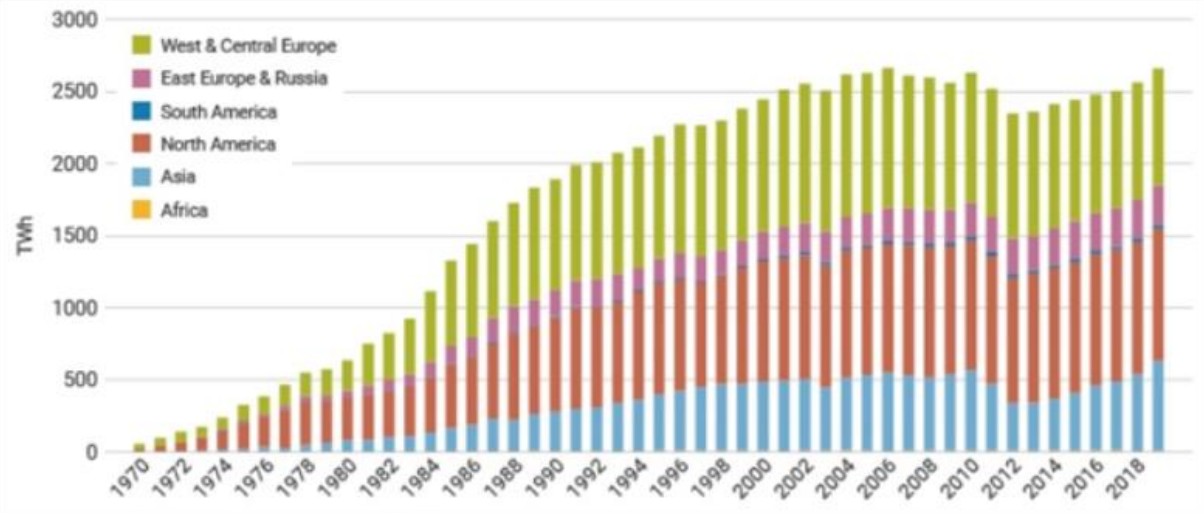

VENTURE CAPITALISTS GAVE ME MONEY TO START A WEB-BASED BUSINESS.
www.dilbert.com scottadams@aol.com
DO THEY KNOW YOU'RE LAZY AND DISHONEST?
IT DIDN'T COME UP.
© 1999 United Feature Syndicate, Inc.
WHAT'LL YOU CREATE... BESIDES ACCOUNTING IRREGULARITIES?
THAT'S ALL I HAVE THE ENERGY FOR.



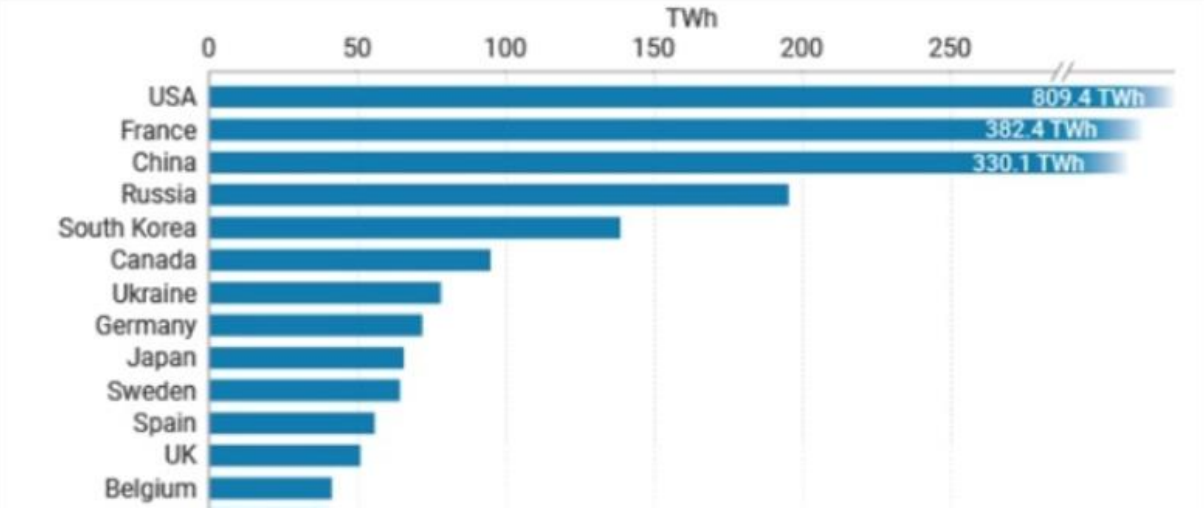
- In 2006, the Energy Watch Group of Germany studied world uranium supplies and issued a report concluding that, in its most optimistic scenario, the peak of world uranium production will be achieved before 2040. If large numbers of new nuclear power plants are constructed to offset the use of coal as an electricity source, then supplies will peak much sooner. Thomas Seltmann, “Nuclear Power: The Beginning of the End,” *Sun & Wind Energy* (Energy Watch Group, November 2009).
- Today, there are some 441 nuclear power reactors operating in 30 countries. These 441 reactors, with combined capacity of over 376 Gigawatts (One GWe equals one billion watts or one thousand megawatts), require 69,000 tonnes of uranium oxide (U3O8).
- According to the World Nuclear Association, about 58 power reactors are currently being constructed in 14 countries. In all there are over 148 power reactors planned and 331 more proposed with Japan intending to shut down its 51 reactors. Each GWe of increased capacity will require about 195 tU per year of extra mine production – three times this for the first fuel load.
- In 2008, mines supplied 51,600 tonnes of uranium oxide concentrate containing 43,853 tU, which means mining supplied roughly 75% of nuclear utility power requirements. The remaining supply deficit used to be made up from stockpiled uranium held by nuclear power utilities, but their stockpiles are pretty much depleted. Mine production is now primarily supplemented by ex-military material - the Megatons to Megawatts program which ends in 2013 - the Russians have stated that the agreement will not be renewed.
- The world only has about 70 years' supply of reactor-grade uranium left at current consumption. New reactors are projected to add an incredible 42% more nuclear power plants within the next decade to 15 years. That means our uranium supply will fall even faster albeit there is hope as we currently do not have the technology to use most of the energy embodied in uranium or to use thorium.
- “If all the world’s electricity was nuclear-generated, the supply of accessible uranium would be exhausted in nine years.” (source Dr. Helen Caldicott, https://www.helencaldicott.com/)

- http://www.zerohedge.com/news/2016-10-02/fukushima-radiation-has-contaminated-entire-pacific-ocean-and-its-going-get-worse

The world might go increasingly nuclear – but every cubic mile of oil equivalent (CMO – energy used globally annually) of nuclear energy will require 500 new surface uranium mines; 1,000 new underground uranium mines; and 2,280 nuclear reactor operations.



Nuclear electricity production. Source: World Nuclear Association and IAEA Power Reactor Information Service (PRIS)



https://www.zerohedge.com/markets/uranium-soars-after-sprott-massively-upsizes-buying-program-1bn-13bn

Hydro


EACH OF US MUST DO HIS PART TO SAVE ENERGY.
www.dilbert.com scottadams@aol.com
ZZZZZZ
8/26/01 © 2001 United Feature Syndicate, Inc.
I COULD BUILD A TINY HYDRO-GENERATOR FOR HIS DROOL.

Tapped?

Producing one CMO of energy a year from **hydro power** will require the construction of 153 of China's Three Gorges Dams – or one every four months for the next 50 years. But this number of "undammed" rivers do not exist.

Only a third of world's great rivers remain free flowing, analysis finds

The Guardian

Billions of people rely on rivers for water, food and irrigation, but from the Danube to the Yangtze most large rivers are fragmented and degraded. Untouched rivers are largely confined to remote places such as the Arctic and Amazonia. The assessment, the first to tackle the subject on a worldwide level, examined 12m kilometres of rivers and found that just 90 of the 246 rivers more than 1,000km (621 miles) long flowed without interruption. Click here to continue reading

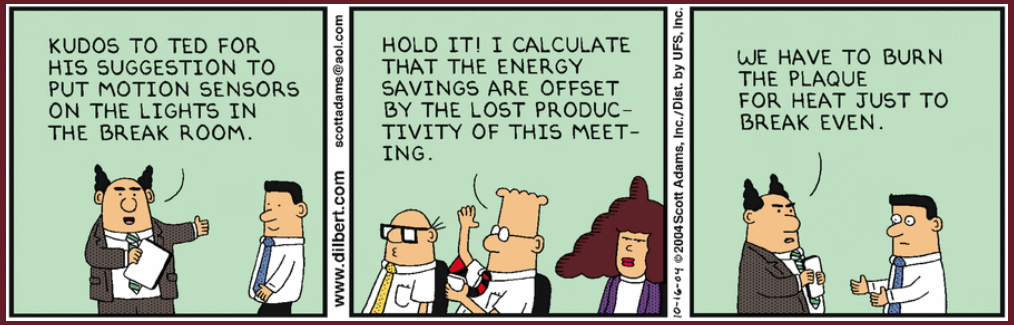
European rivers are littered with barricades, but a movement grows to remove them National Geographic

In a four-year study spanning 36 European countries, scientists surveyed almost 1,700 miles of river by foot—and found at least 1.2 million obstacles preventing European rivers from flowing freely. That's more than one barrier for every mile of river (or 0.74 barriers per kilometer).

Hydro-electric output dropped 14% in 2021 due to lack of moisture

https://www.zerohedge.com/commodities/renewables-not-so-reliable-us-hydropower-plunges-14

Renewables


KUDOS TO TED FOR HIS SUGGESTION TO PUT MOTION SENSORS ON THE LIGHTS IN THE BREAK ROOM.
www.dilbert.com scottadams@aol.com
HOLD IT! I CALCULATE THAT THE ENERGY SAVINGS ARE OFFSET BY THE LOST PRODUCTIVITY OF THIS MEETING.
10-16-04 ©2004 Scott Adams, Inc./Dist. by UFS, Inc.
WE HAVE TO BURN THE PLAQUE FOR HEAT JUST TO BREAK EVEN.

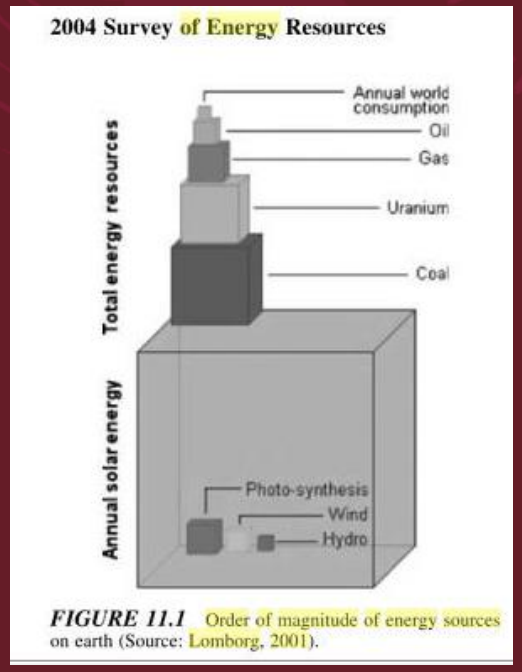
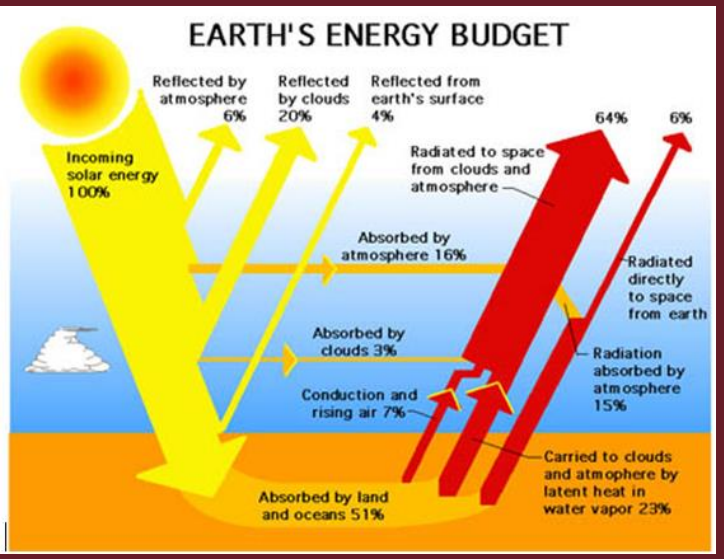


FIGURE 11.1 Order of magnitude of energy sources on earth (Source: Lomborg, 2001).



"All of life, including human life in all of its manifestations, runs principally on contemporary sunlight that enters the top of our atmosphere at approximately 1.4 kilowatts per square meter (5.04 MJ per square meter per hour). Roughly half that amount reaches the Earth's surface. This sunlight does the enormous amount of work that is necessary for all life. The principal work that this sunlight does on the Earth's surface is to evaporate water from that surface (evaporation) or from plant tissues (transpiration) which in turn generates elevated water that falls back on the Earth's surface as rain, especially at higher elevations. The rain in turn generates rivers, lakes, and estuaries and provides water that nurtures plants, animals, and civilizations. Differential heating of the Earth's surface generates winds that cycle the evaporated water around the world, and sunlight of course maintains habitable temperatures and is the basis for photosynthesis in both natural and human-dominated ecosystems. These basic resources have barely changed since the evolution of humans (except for the impacts of the ice ages) so that preindustrial humans were essentially dependent upon a constant although limited resource base. Over time humans increased their ability to exploit larger parts of that natural solar energy flow through technology, initially with spear points, knives, and axes that could concentrate human muscular energy, and then with agriculture and dams, and now with fossil fuels. The development of agriculture allowed the redirection of photosynthetic energy captured on the land from the many diverse species in a natural ecosystem to the few species of plants (called cultivars) that humans can and wish to eat, or to the grazing animals that humans controlled. Curiously the massive increase in food production per unit of land brought on by agriculture did not, over the long run, increase average human nutrition but mostly just increased the numbers of people."

What's It Gonna Take?

- Producing one CMO of electricity from **wind** will require three million two-megawatt wind turbines. These turbines would occupy 580,000 acres of combined space.
- "On a percentage basis, renewables take the gold for growth recently with an impressive rate of 13% per year since 2010. But from an absolute perspective the news is more sobering: systems like wind, solar and biomass are not taking market share away fast enough to make a difference to disconcerting metrics like carbon intensity. Because coal and natural gas are also growing at a good clip, on massively higher volumes, the share of renewables in the world's energy diet (currently 1.4%) is increasing by 0.1% per year. That means that unless something changes, under current conditions it's going to take 1,000 years to put the fossil fuel industry to bed! Arc Financial July 2, 2013

	abundance	difficulty	intermittency	demonstrated	electricity	heat	transport	acceptance	backyard?	efficiency	Score
Solar PV						via electric	via electric				5
Solar Thermal			some storage				via electric				5
Solar Heating			some storage								4
Hydroelectric			seasonal flow			via electric	via electric	not universal	micro-hydro		4
Biofuel/Algea		gunk/disease		some R&D	mis-spent				small scale?		4
Geothermal/Electricity	hotspots						via electric				4
Wind						via electric	via electric	noise, birds, eyesore			3
Artificial Photosynth.		catalysts		active devel.	mis-spent				?		3
Tidal			daily/monthly variations			via electric	via electric				3
Conventional Fission		high-tech					via electric	waste/fear			2
Uranium Breeder		high-tech		military			via electric	proliferation			2
Thorium Breeder		high-tech					via electric	waste/fear			2
Geothermal/Depletion		deep drill		rarely?				deep wells	impractical		2
Geothermal/Heating		deep drill		rarely?				deep wells	impractical		1
Biofuel/Crops	food / cellulosic	annual harvest	seasonal	ethanol, etc. / R&D effort	mis-spent			food/land competition	small beans		1
OceanThermal		access/ maintenance				via electric	via electric				1
Ocean Current		access/ maintenance				via electric	via electric				1
Ocean Waves			storms/lulls	many one-off designs		via electric	via electric	eyesore			1
D-T Fusion	lithium	future-tech					via electric	trit/neutron contamination			1
D-D Fusion		farther future					via electric				1

Yellow boxes tend to deserve explanation. It is usually clear why something would swing red or green, but yellow often has several things tugging at it. If green boxes are given a +1 score, yellow boxes zero, and red boxes -1, adding the boxes with equal weight yields the scores on the right, by which measure the table is sorted: best to worst. The only place I cheated was to give D-D fusion a -2 for difficulty. It's the hardest thing on the list, given our decades of massive effort invested to date on D-T fusion, while D-D is too hard to even attempt.

U.S. primary renewable energy consumption by source and sector, 2019

Quadrillion British thermal units (Btu)

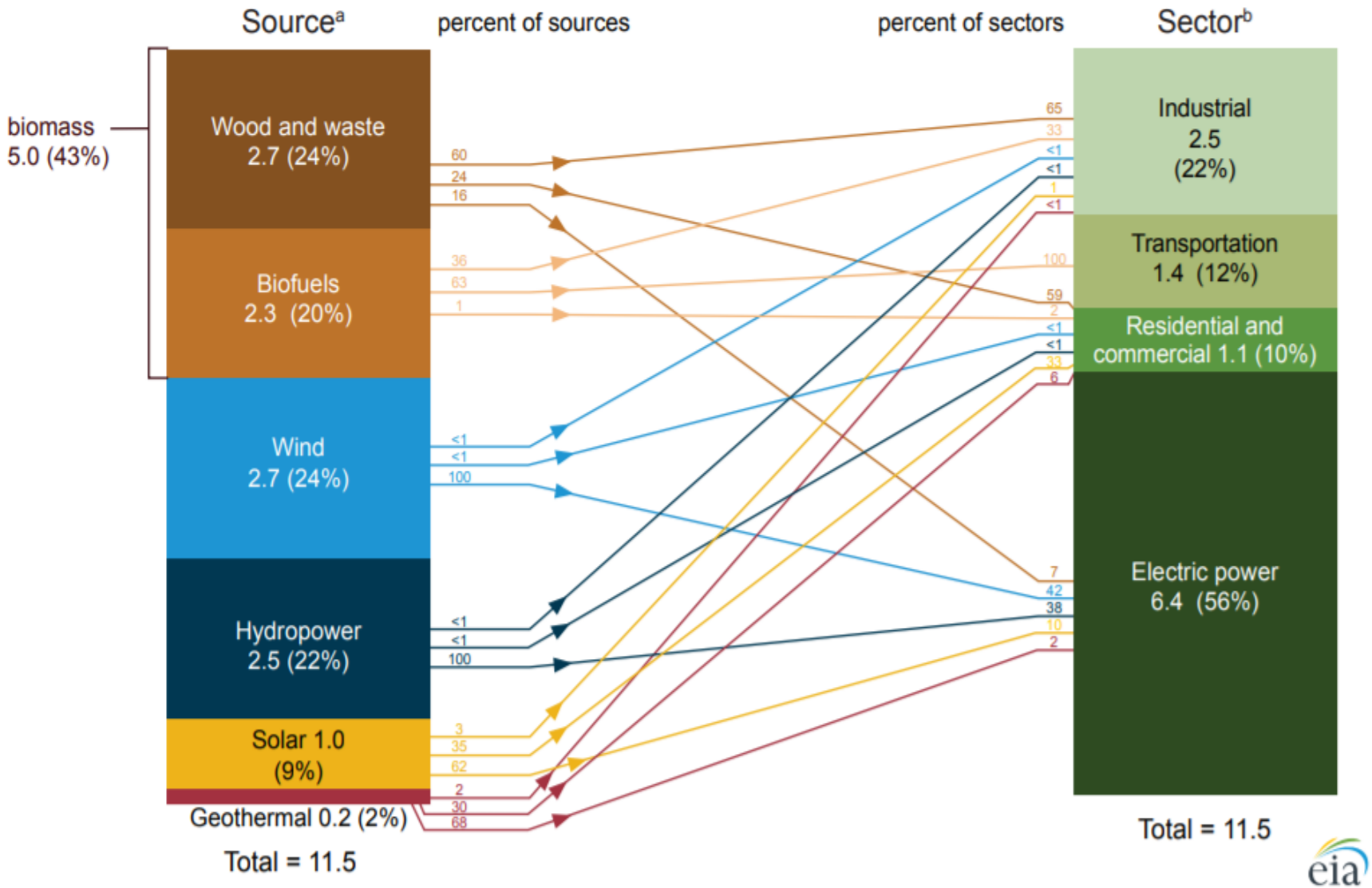
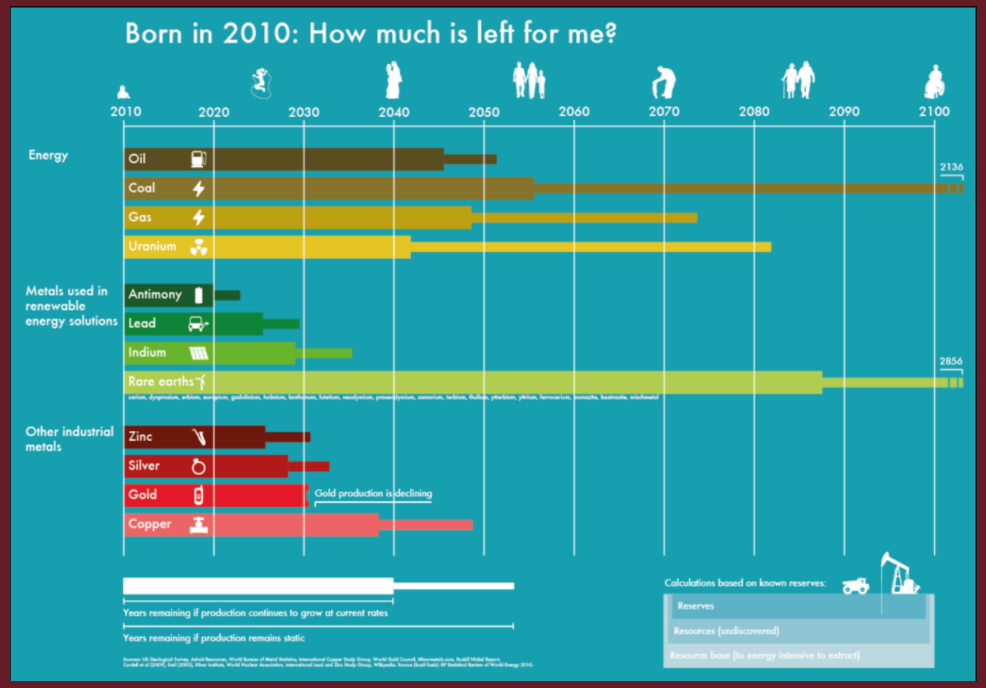
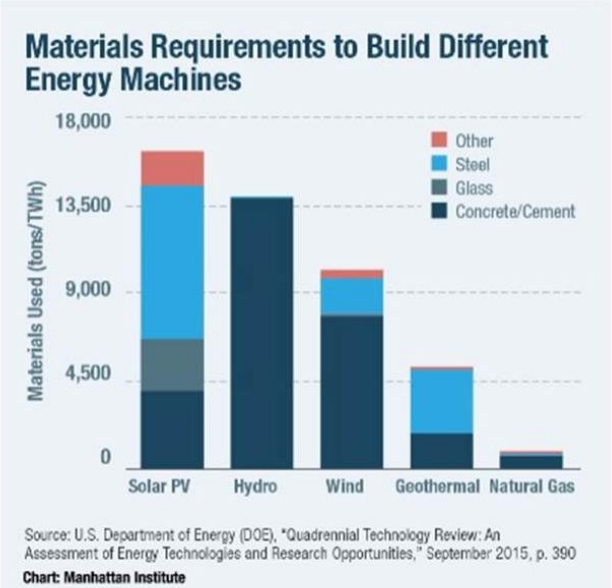


Table 1: Sectoral Shares of Renewable Energy in Recent Global Scenarios

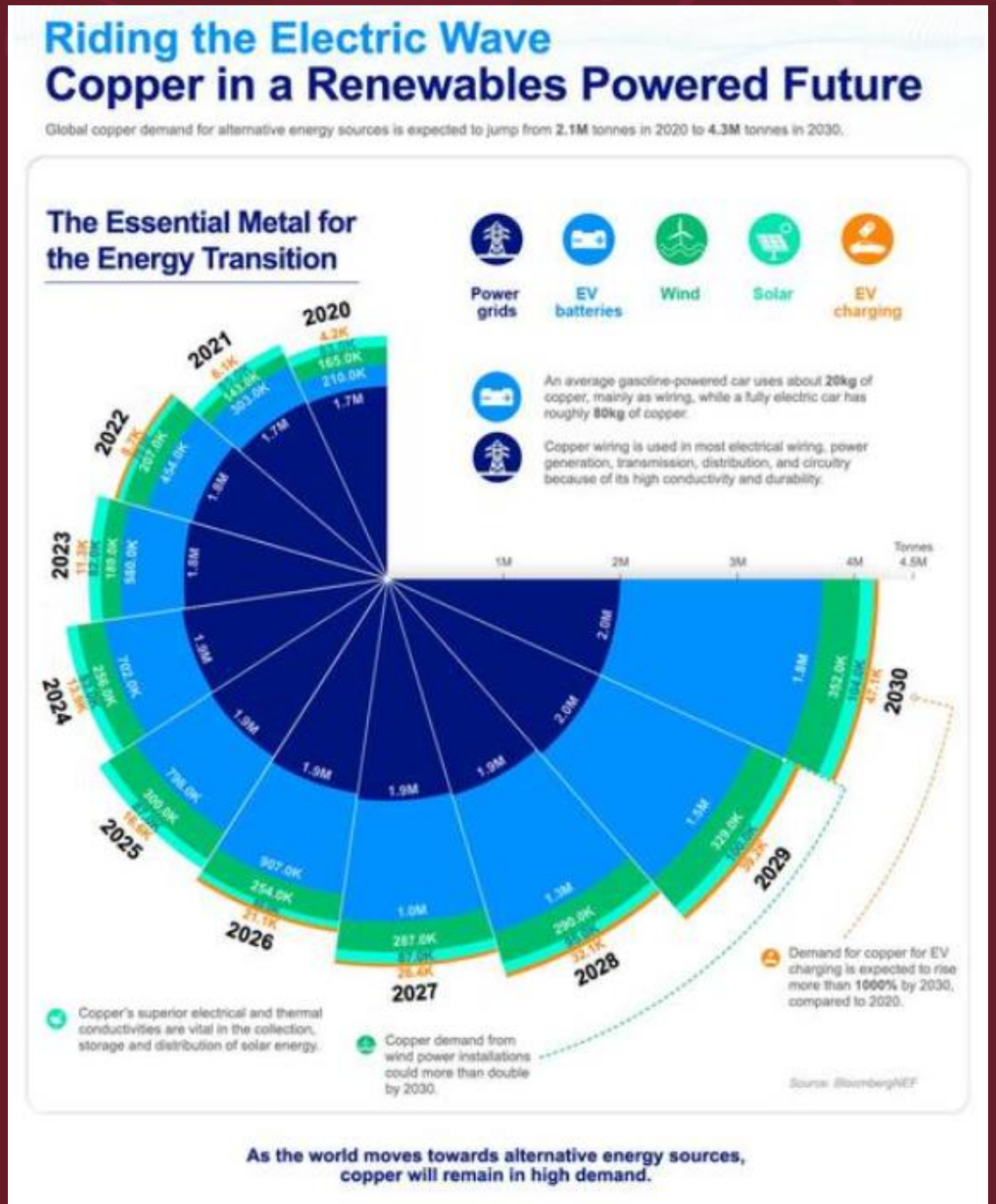
Scenario	By Year	Electricity	Heat	Transport
By 2030–2040				
ExxonMobil *Outlook for Energy: A View to 2040* (2012)	2040	16%	—	—
BP *Energy Outlook 2030* (2012)	2030	25%	—	7%
IEA *World Energy Outlook* (2012) "New Policies"	2035	31%	14%	6%
IEA *World Energy Outlook* (2012) "450"	2035	48%	19%	14%
Greenpeace (2012) *Energy [R]evolution*	2030	61%	51%	17%
By 2050				
IEA *Energy Technology Perspectives* (2012) "2DS"	2050	57%	—	39%
GEA *Global Energy Assessment* (2012)	2050	62%	—	30%
IEA *Energy Technology Perspectives* (2012) "2DS High Renewables"	2050	71%	—	—
Greenpeace (2012) *Energy [R]evolution*	2050	94%	91%	72%
WWF (2011) *Ecofys Energy Scenario*	2050	100%	85%	100%





Materials required to build solar PV, hydro, wind, geothermal and natural gas machinery. Source: Manhattan Institute


Lithium mining plant
Finished Pipeline



https://www.zerohedge.com/commodities/visualizing-copper-demand-renewables-powered-future

COPPER'S ROLE IN RENEWABLE ENERGY

Copper is critical for renewable energy technologies with applications in cabling, wiring, heat-exchange, and more.

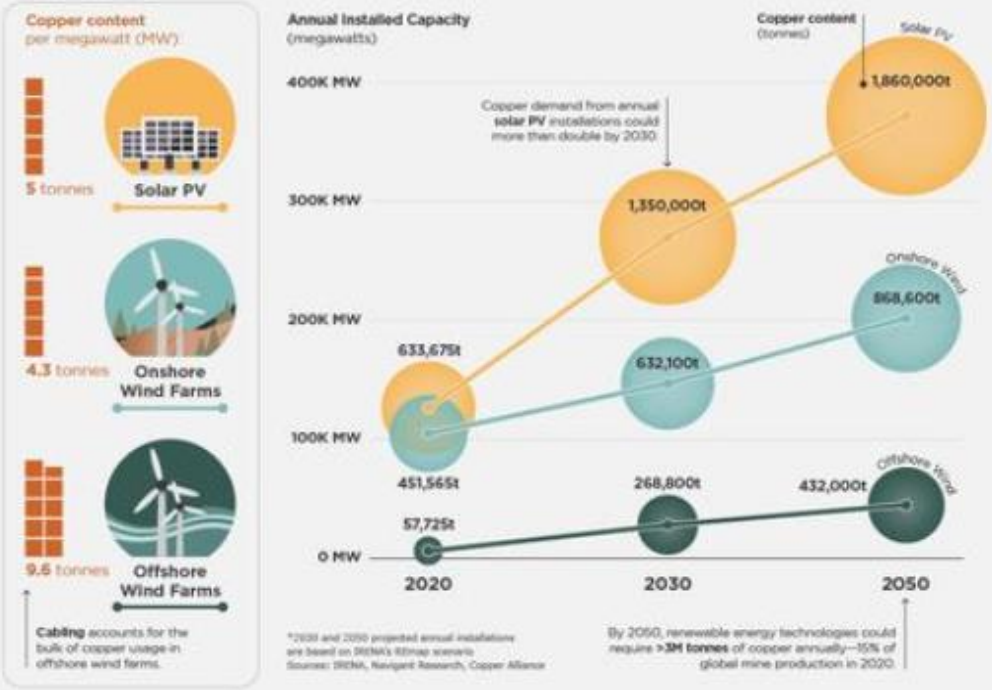
GOVERNMENTS around the world are taking action to accelerate the energy transition.

As of 2020, there were:

- **617** Cities with **100% renewable energy targets**
- **1,852** Cities with **climate emergency declarations**
- **>10,500** Cities with **emission reduction targets**

The Copper Intensity of Renewable Energy

As the adoption of solar and wind technologies grows, so will the need for copper.



This demand represents just three technologies, and the overall copper market is expected to be in a >500,000-tonne deficit in 2021.

New copper mines and additional mining capacity will play a key role in meeting copper's rising demand.

VISUAL CAPITALIST

Sources: REN21, IRENA, Navigant Research, Citigroup via Bloomberg

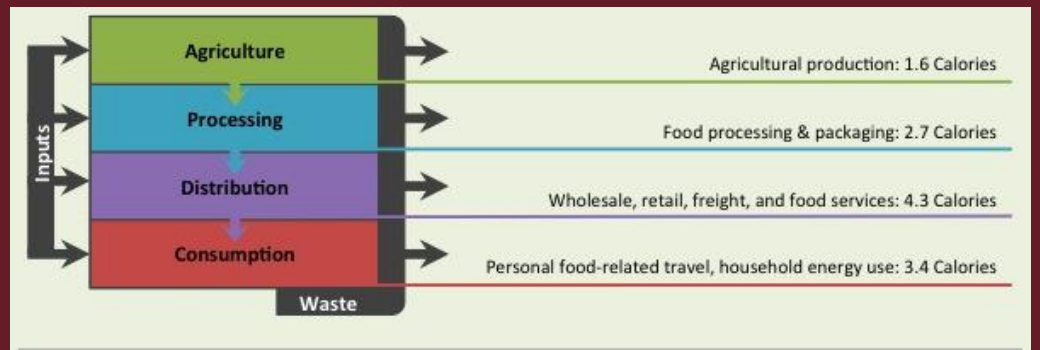
TRILOGY metals inc

www.trilogymetals.com

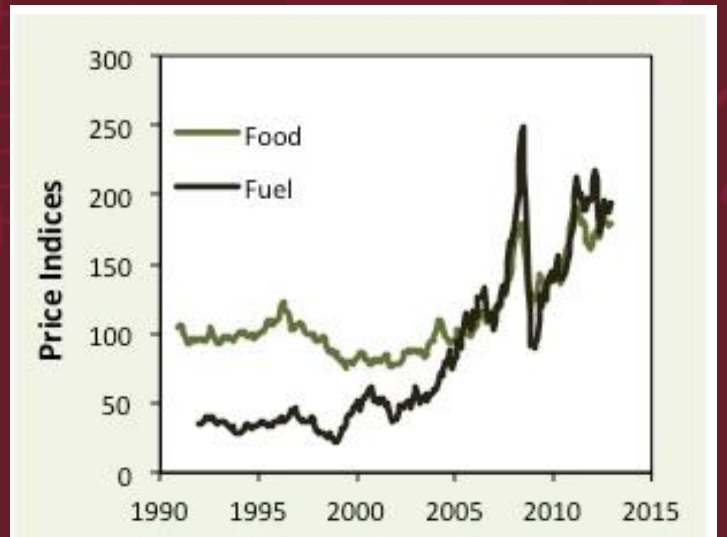
Some basic energy costs:

- One metric ton of cement = 5.1 GJ
- One metric ton of glass = 5.3 GJ
- One metric ton of steel = 21.3 GJ
- One metric ton of aluminum = 64.9 GJ
- One MT of potassium fertilizer = 13.8 GJ
- One MT of phosphorus fertilizer = 17.5 GJ
- One MT of nitrogen fertilizer = 78.2 GJ

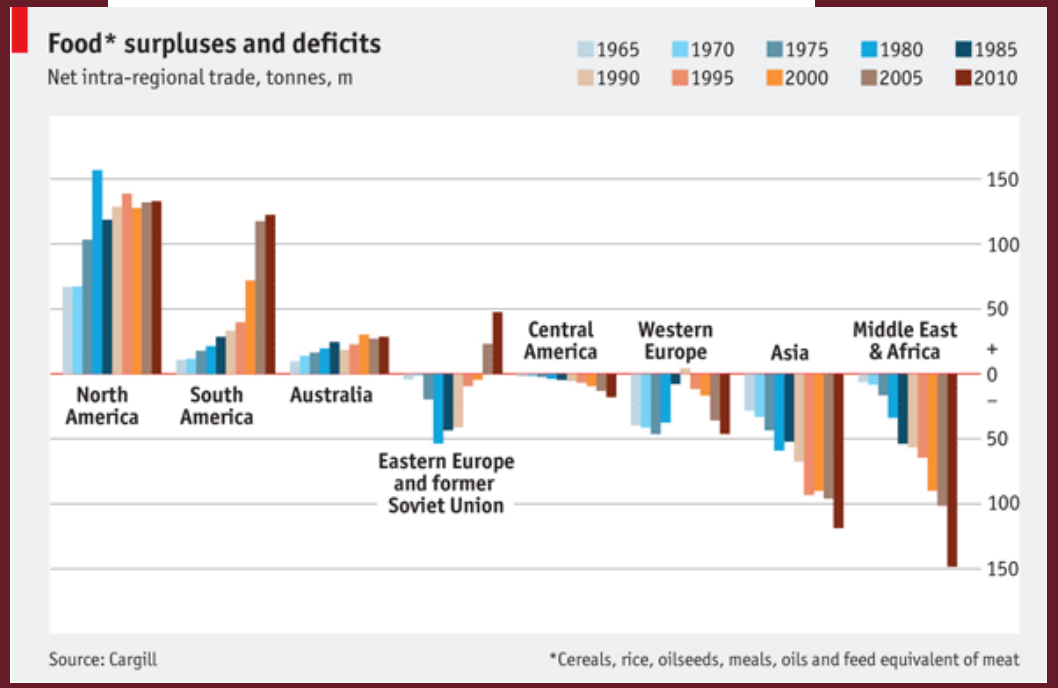
Source: R. L. Jaffe and W. Taylor Energy info card, Physics of energy 8.21, Massachusetts Institute of Technology.



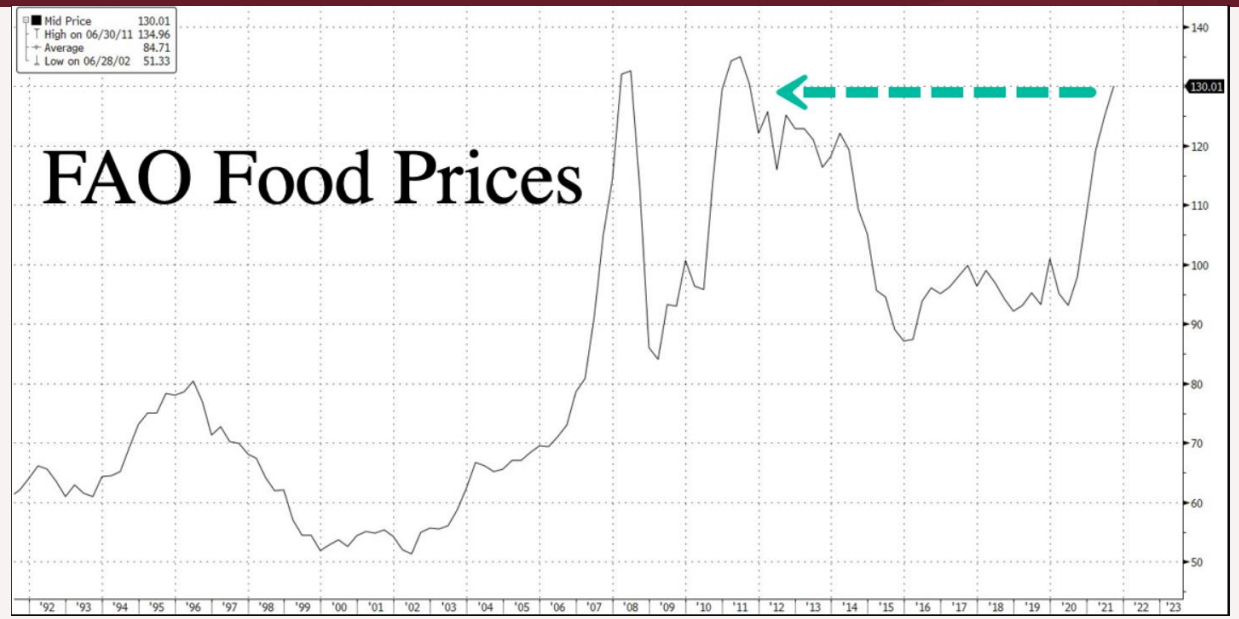
U.S. food system energy use in 2002. Sources: Canning et al. (2010), USDA Economic Research Service.



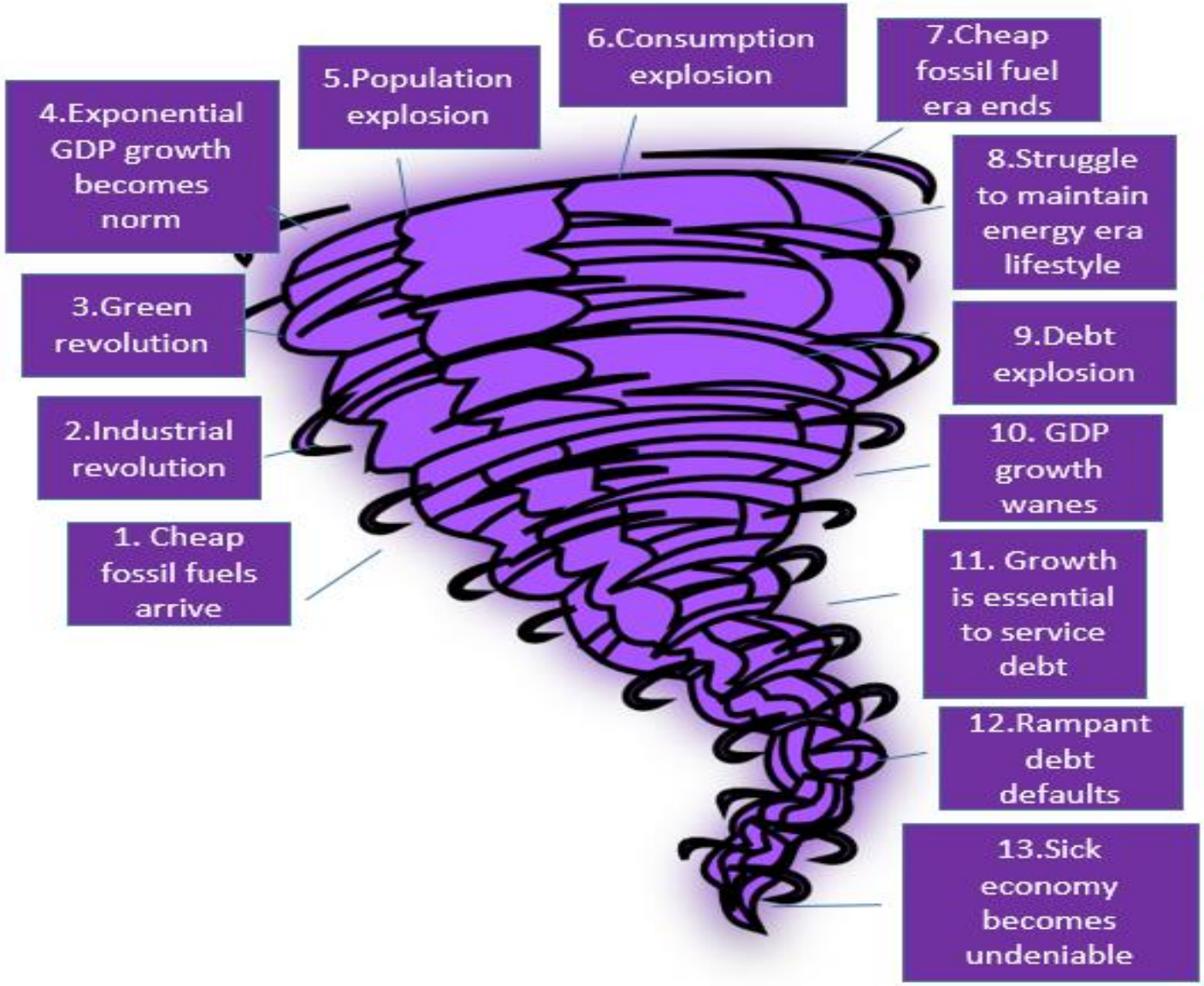
Food and fuel prices show a strong correlation, particularly after 2005. Source: International Monetary Fund.



There is no green revolution without natural gas derived nitrogen fertilizer



Challenge – Perfect Storm



SEER ENERGY

Fig. 5.14: High EROEI

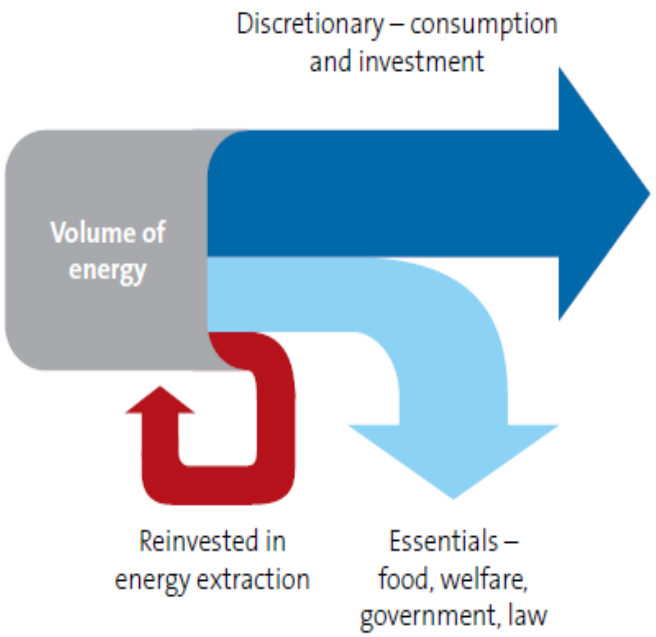
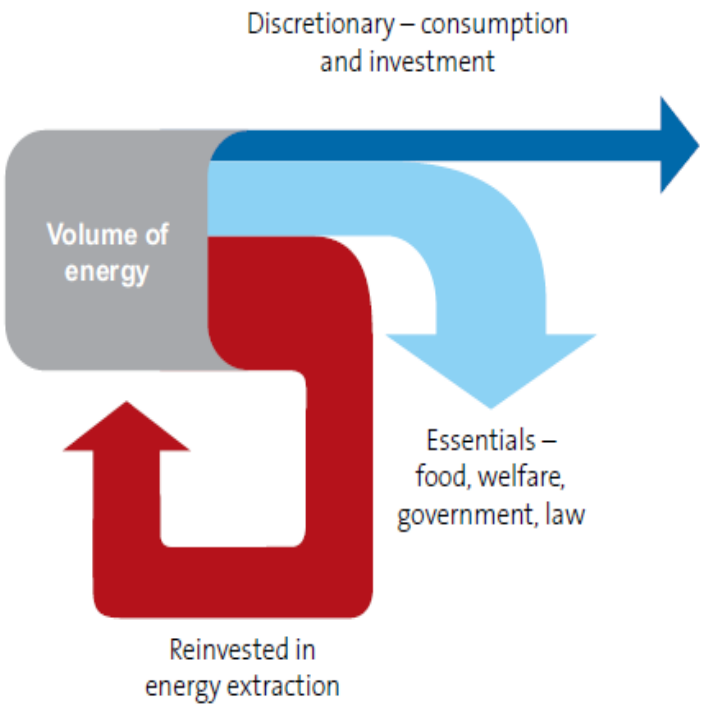
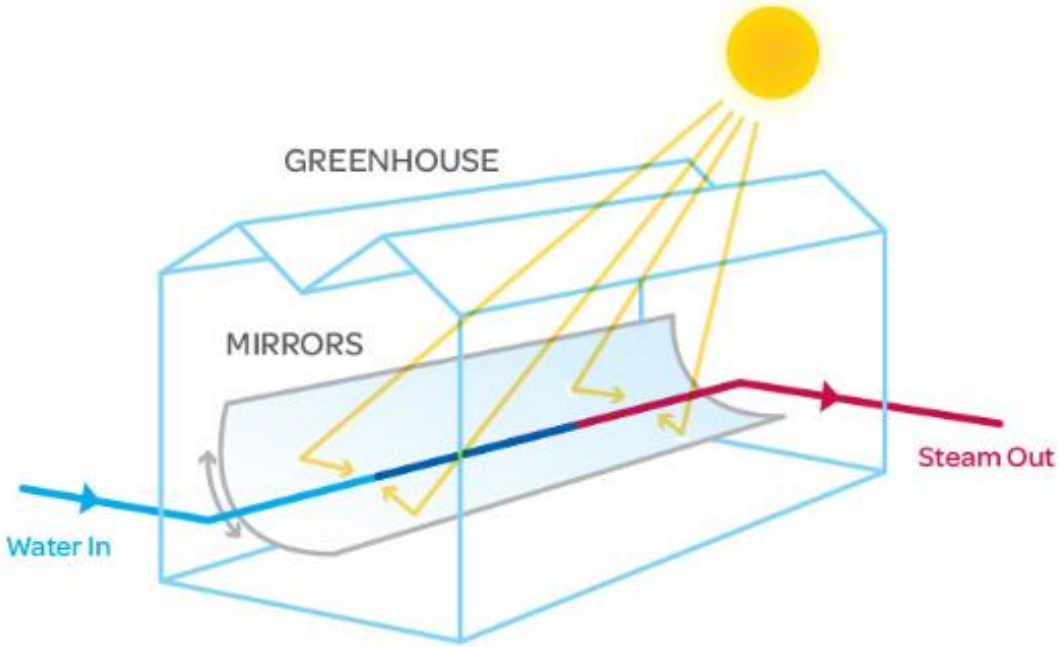


Fig. 5.15: Low EROEI



* Source: Tullett Prebon estimates, see text

How enclosed troughs work



STEP ONE
There are no solar panels in a GlassPoint system. Instead, large curved mirrors are suspended inside an agricultural greenhouse.

STEP TWO
The mirrors automatically track the sun throughout the day, focusing sunlight on a stationary boiler tube containing water.

STEP THREE
The concentrated sunlight heats the water to efficiently produce high-pressure steam.

- Concentrated solar thermal technology provides zero-carbon steam at a lower cost due to no fuel cost in sunny locations around the world for enhanced oil and gas recovery.

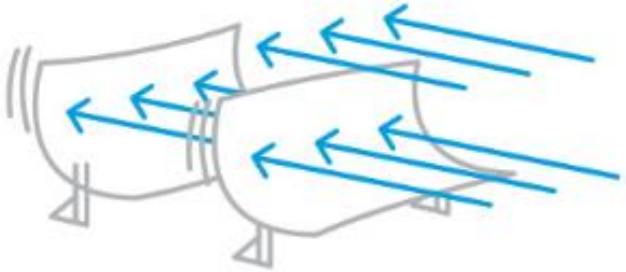
ARK
Agro Resilience Kit Ltd.
www.arkltd.net

Solar PV Comparison

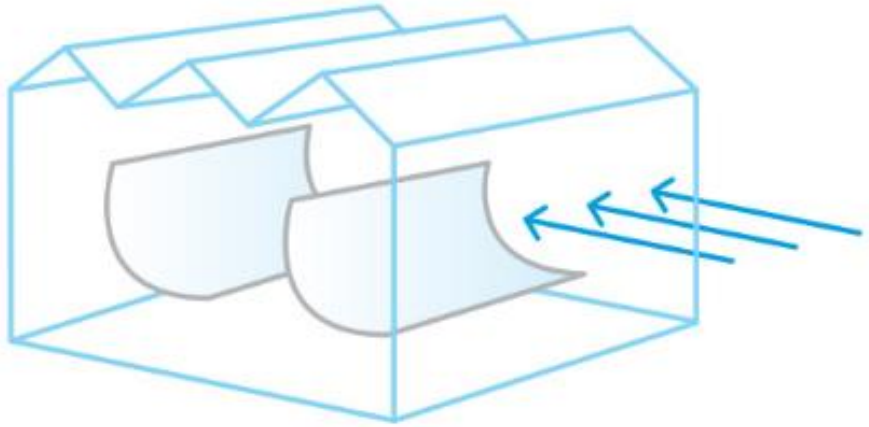
Concentrated Solar Plant vs Solar PV farm			
	CSP	PV	Comment
Capacity - MW	100	100	
Sunlight converstion (watts/square meter)	500	200	PV is 200 and solar thermal is 700
Solar collection Area	200,000	500,000	
site collection area ratio	2	0.5	stacked csp vs spaced solar farm
Site Area required (m2)	100,000	1,000,000	
Site area required (acres)	25	247	
investment rate per watt	0.40	1.50	
plant cost ($millions)	40	150	

Wind is the main cost driver

Every trough needs to be reinforced against the wind.



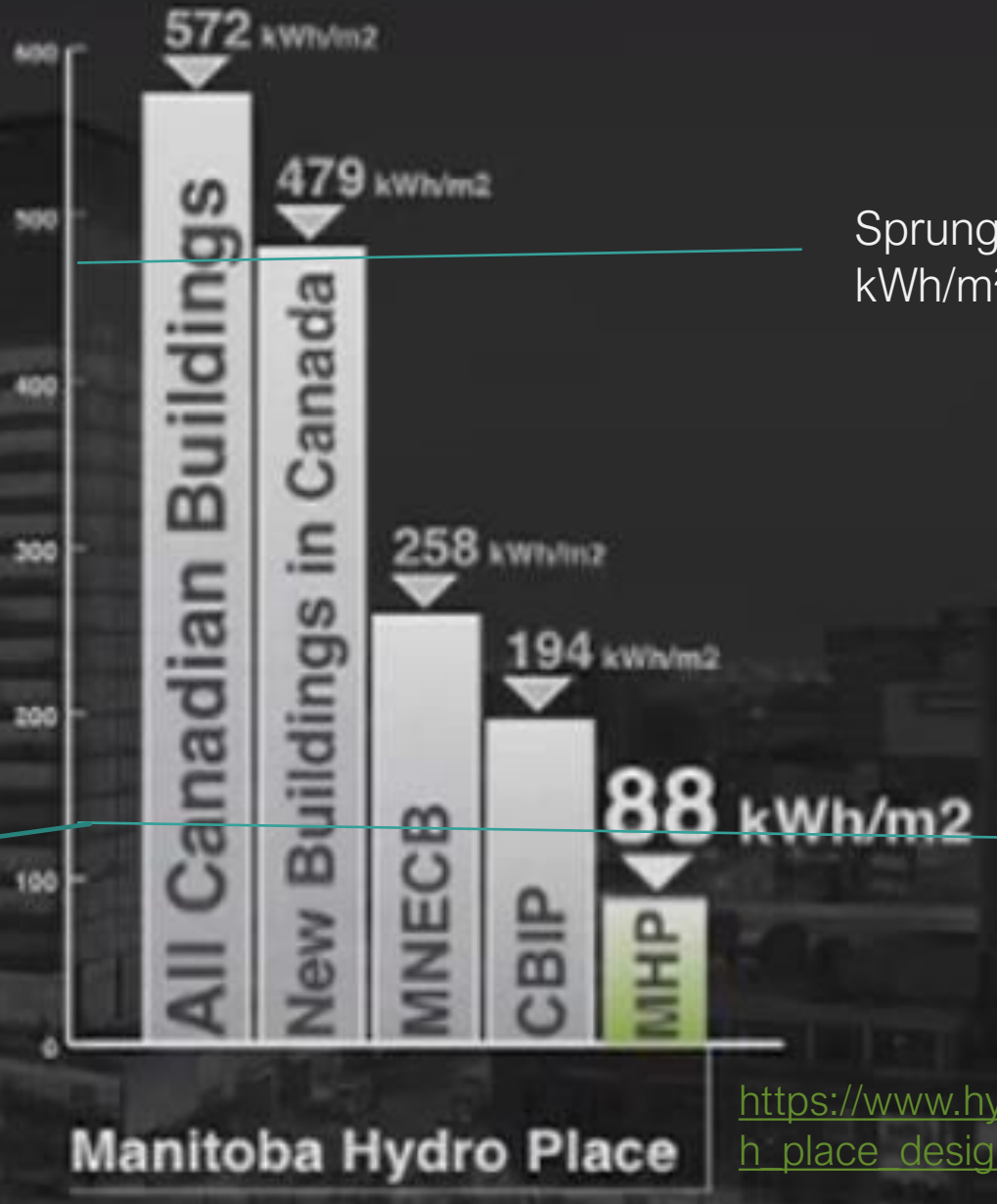
Only the outside wall needs to be reinforced against the wind.



Exposed solar designs use up to two times as much steel and concrete as GlassPoint's enclosed trough.

- Conventional greenhouse structures typically see heat loss double as wind speed goes from 0 to 15 miles per hour

Benchmark numbers for the greenest buildings in Canada



Sprung Campus @ 474 kWh/m²/yr.

ARK Sprung Greenhouse @ 133 kWh/m²/yr.

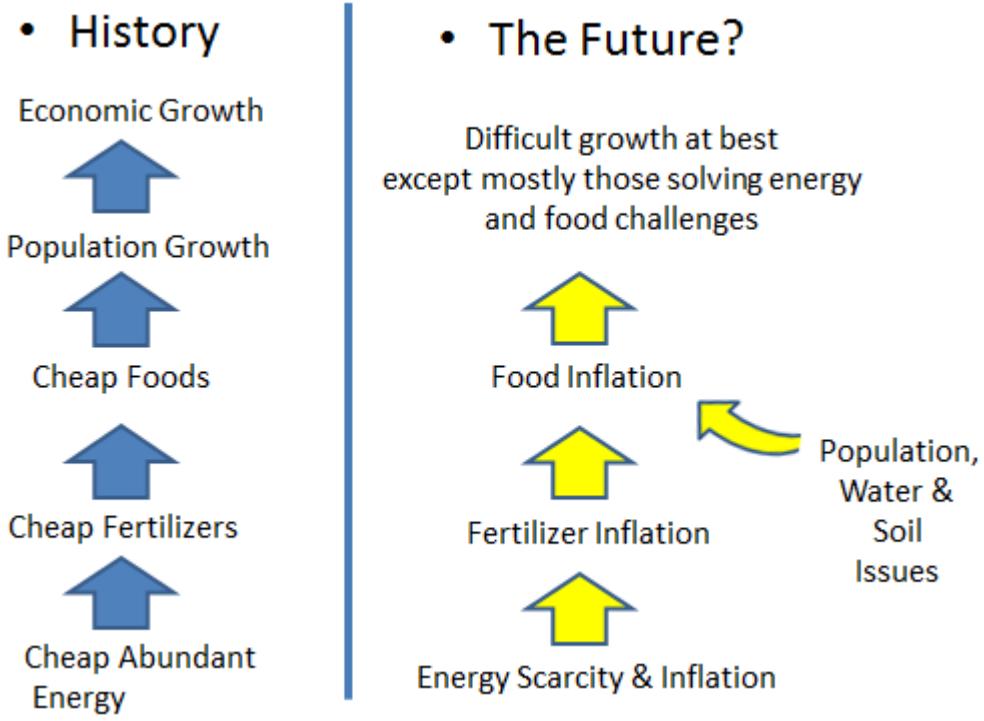
This was before concentrated solar, etc. Entirely off grid renewable is in our grasp!

https://www.hydro.mb.ca/corporate/history/mh_place_design_and_construction

Energy use of Canadian buildings

Permaculture Design For Our Future

That



Or This

ARK
Agro Resilience Kit Ltd.
www.arkltd.net

1. Gain of rooftop acreage with little transport required
2. Role of small business in decentralized production
3. Virtually free greenhouse cooling
4. Virtually free passive solar greenhouse heating
5. Composting for heating, nutrient reuse and biogas
6. Aquaponics to solve overfishing and reduce produce fertilizer costs
7. Concentrated solar
8. Cogen to quadgeneration for energy efficiency
9. Algae greenhouse for new fast replenishment fuels
10. Only a fragment of what permaculture has to offer

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That or This

No Alternative To Energy Efficiency