Presentation at PROBUS North Club

9 April 2018 ~ 9:30 a.m.

Photo Source: http://www.tiffanyraecoaching.com/mentoring/

Global Warming & Climate Change
Perspectives on World Energy

By Stan Ridley

(GW&CC Intro. then Agenda)

Agenda

- Background
- Long Journey from Muscle Power Age to Fossil Fuel Age
- So Many Became Relatively Rich
- Global Warming & Climate Change “Size-Up”
- IPCC and NASA etc.
- Our Have & Have Not World
- Fossil Fuels & Conversion Systems (Coal, Oil, Nat. Gas & “Fracked” Shale Gas)
- Renewables & their Conversion Systems
- Possible “Breakthrough” Solutions (Storage Systems, CCS, New “Breed” Nuclear & Other)
- Social and Political Perspectives
- Suggested Ways Forward

(*References*)

Main Reference Sources

- The World Bank
- The United Nations
- US - Energy Information Administration (EIA)
- US Census Bureau
- International Energy Agency (IEA)
- B.P. Statistical Review of World Energy
- The European Environment Agency (EEA) of the European Union (EU)
- US National Aeronautics and Space Administration (NASA)
- US National Oceanic & Atmospheric Administration (NOAA)
- IPCC ~ Intergovernmental Panel on Climate Change (IPCC) by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO)

(The Microwave)

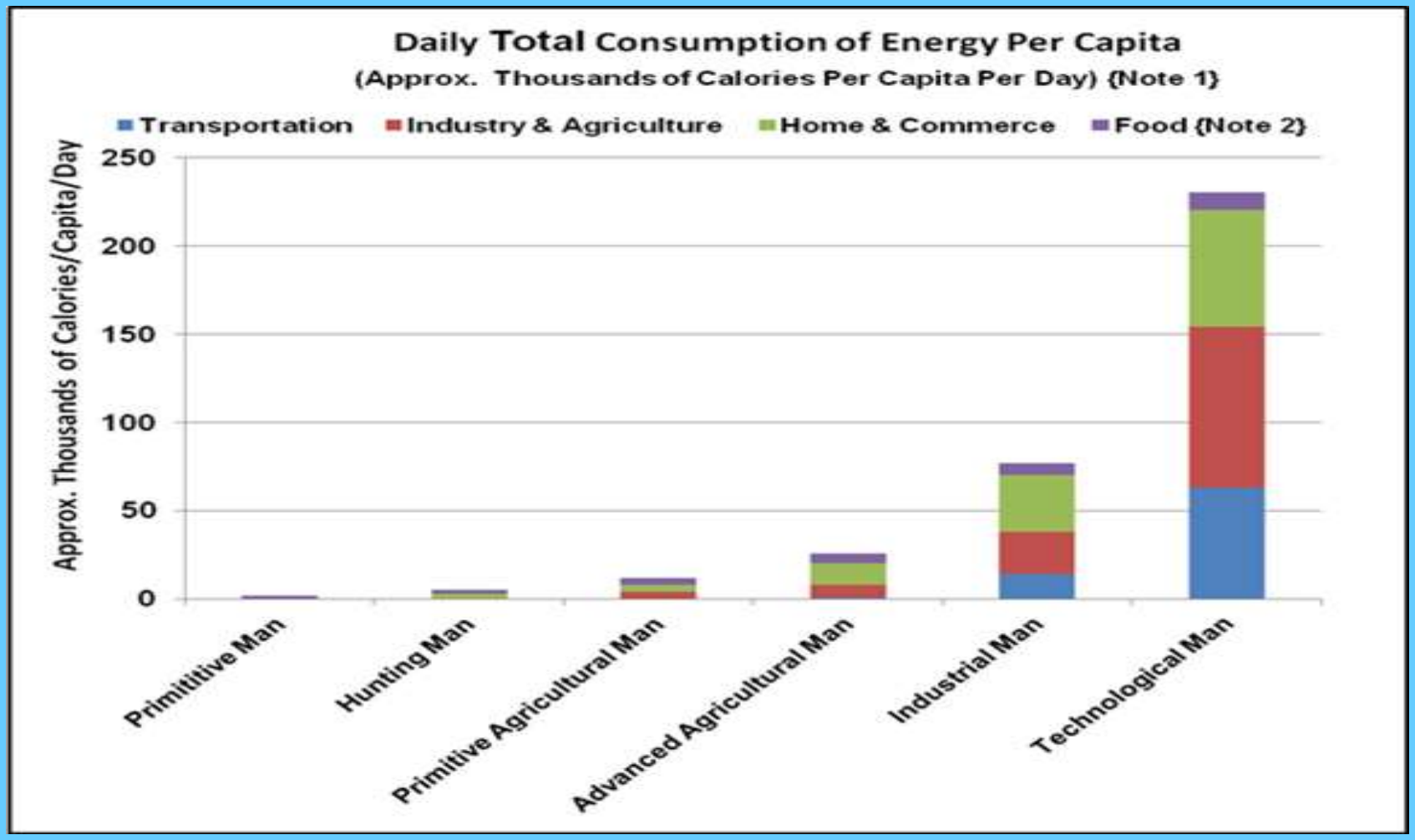
(12,000 years with Energy)

Our Million Year Journey with Energy

Photo Source: Journey of Man by: Spencer Wells

(Calories / Capita / Day)

Estimated Daily Consumption of Energy per Capita at Different Historical Points

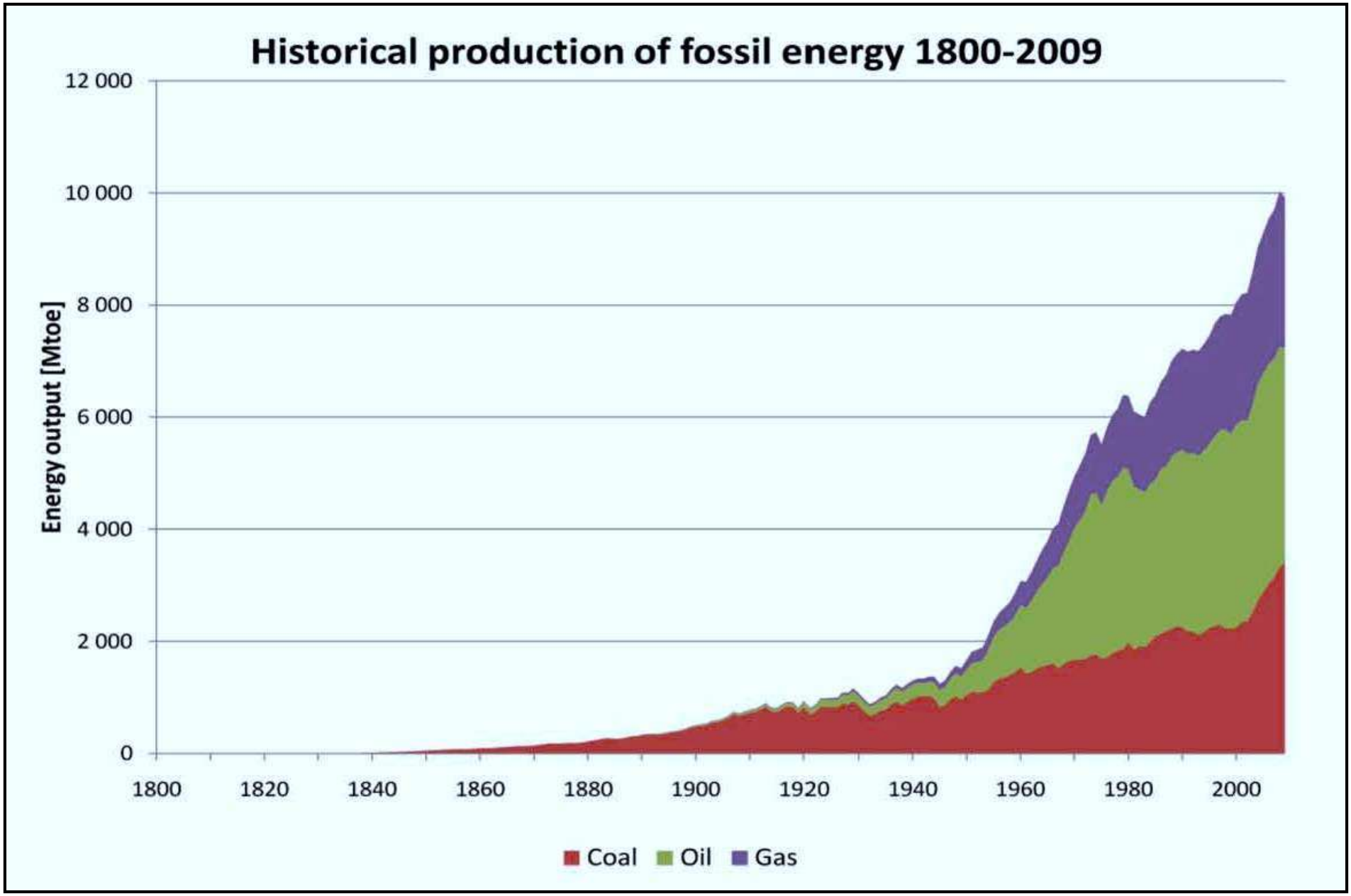


Note 1: *1 Calorie = 1 kilo calorie.*

Note 2: *The total Calorie intake shown here includes both direct and indirect energy use by humans, including the energy to produce the food + the actual direct energy content of the food.*

Source: *https://www.wou.edu/las/physci/GS361/electricity%20generation/HistoricalPerspectives.htm*

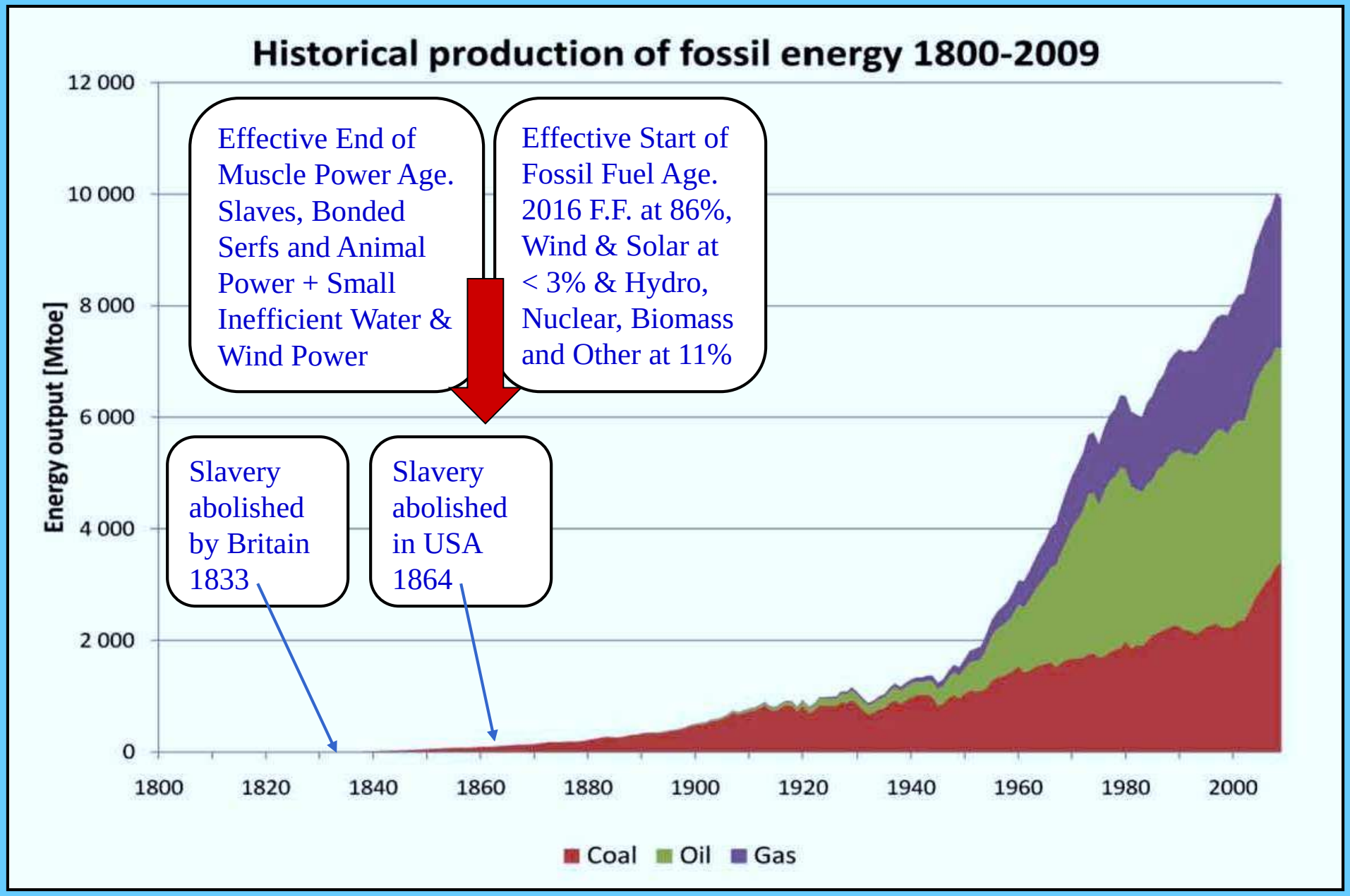
Adapted from: E. Cook, "The Flow of Energy in an Industrial Society" Scientific American, 1971 *(Total Fossil Fuel Use)*



Note: *[“Mtoe”] Stands for “Million Tonnes of Oil Equivalent”.*

Source: *http://www.intechopen.com/books/climate-change-research-and-technology-for-adaptation-and-mitigation/fuelling-future-emissions-examining-fossil-fuel-production-outlooks-used-in-climate-models.*

(End of Slavery)



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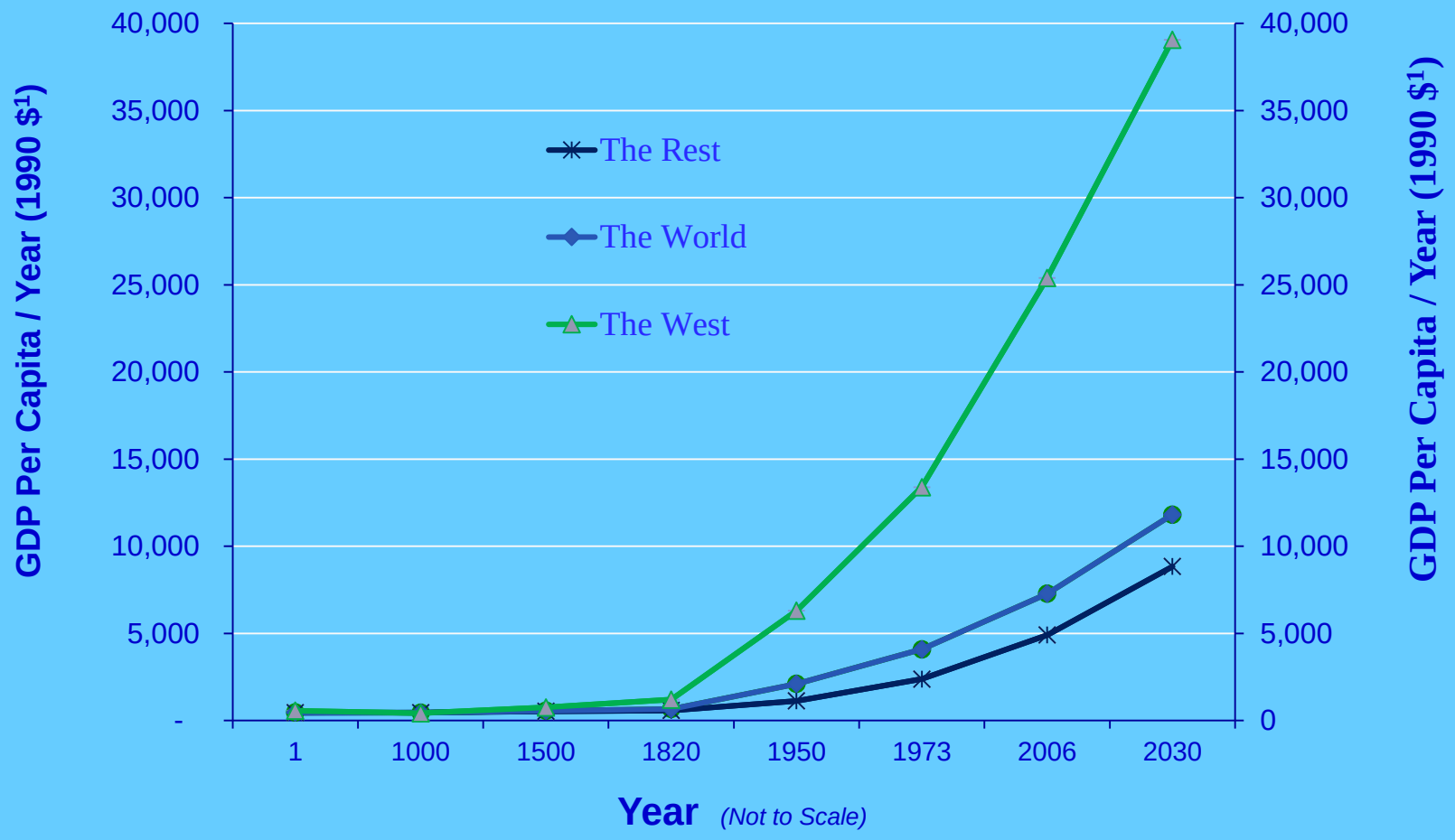
(Resulting Wealth & Energy)

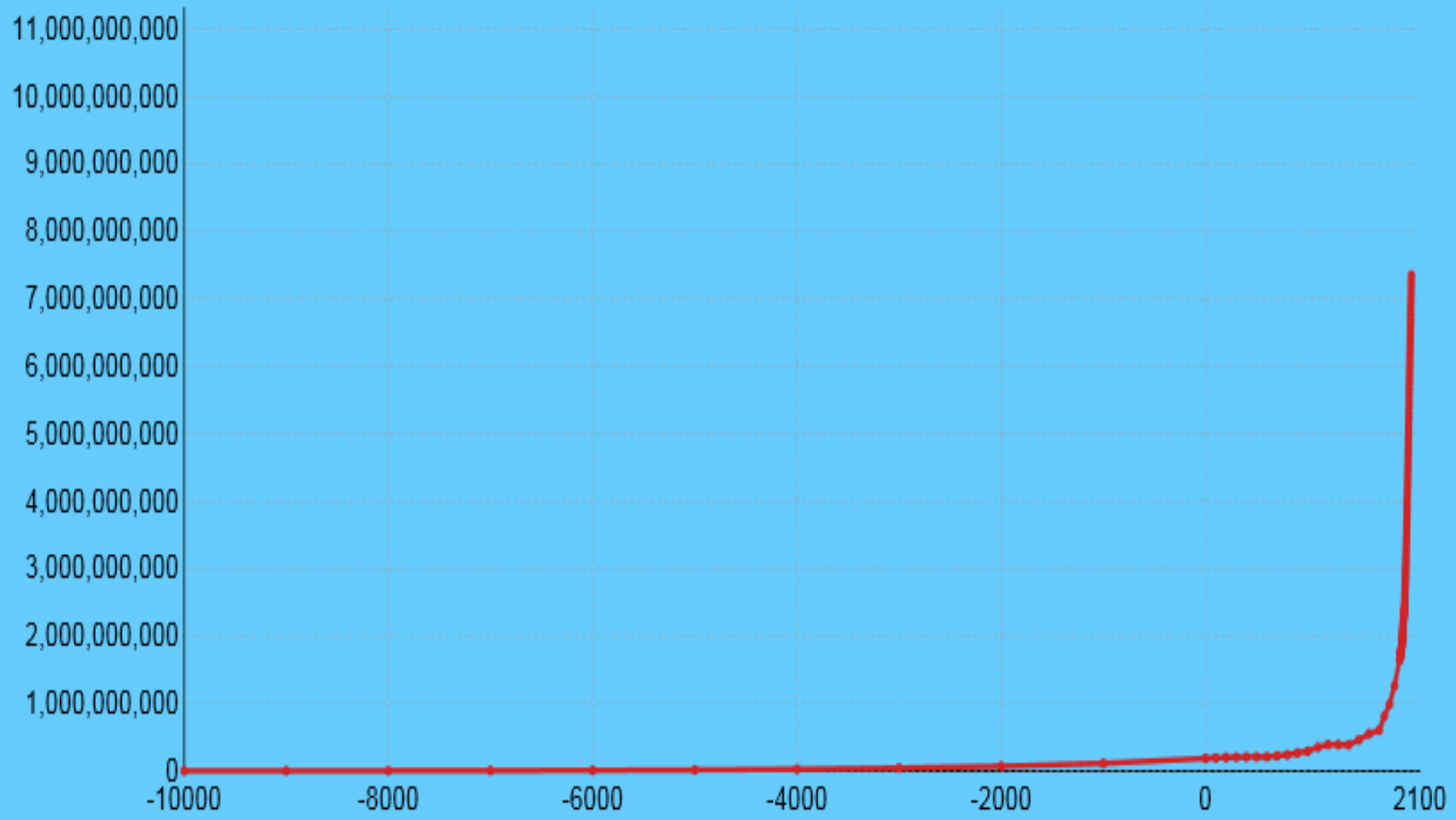
World Per Capita GDP from 1 AD to 2030 AD



Note 1: *The Geary–Khamis dollar, more commonly known as the international dollar, is a hypothetical unit of currency that has the same purchasing power parity (PPP) that the U.S. dollar had in the United States at a given point in time. It is widely used in economics.*

Sources: *Angus Maddison, World Economics, Vol. 9, No. 4, Oct-Dec 2008.* *(Population)*

World Population Estimates 10,000 BCE to 2015



Data source: World Population over 12000 years (various sources), Medium Projection – UN Population Division (2015 revision)

OurWorldInData.org/world-population-growth/ • CC BY-SA

(Water, Food, Shelter & Energy)

Water, Food, Shelter & Energy & Power are the Cornerstones of Our Human Existence

- In the last two hundred years Energy & Power have become essential to our existence, well-being and prosperity.

- Energy & Power are increasingly important in producing & supporting the other cornerstones, namely the:

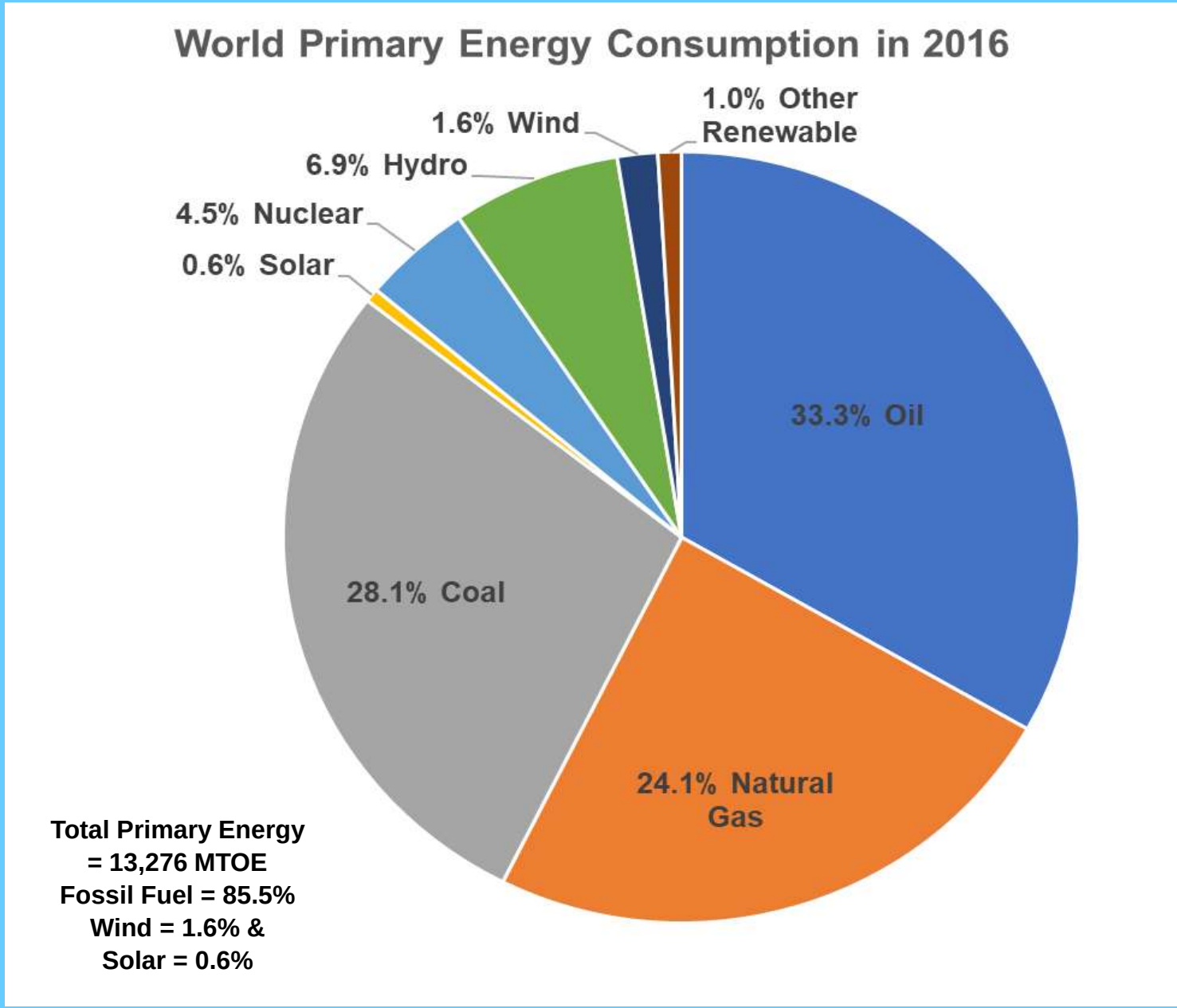
  - Collection and distribution of water

  - Growing, harvesting, storage and distribution of food, and,

  - Production of building materials, construction and operation of dwellings, businesses and factories etc.

  - Electronic, electrical, mechanical and civil/municipal systems etc. that were all brought into existence with energy and power, and without which most societies could not now function.

(Total Energy Pie)



Source: *http://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-full-report.pdf and http://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-renewable-energy.pdf*

(GHG Emissions)

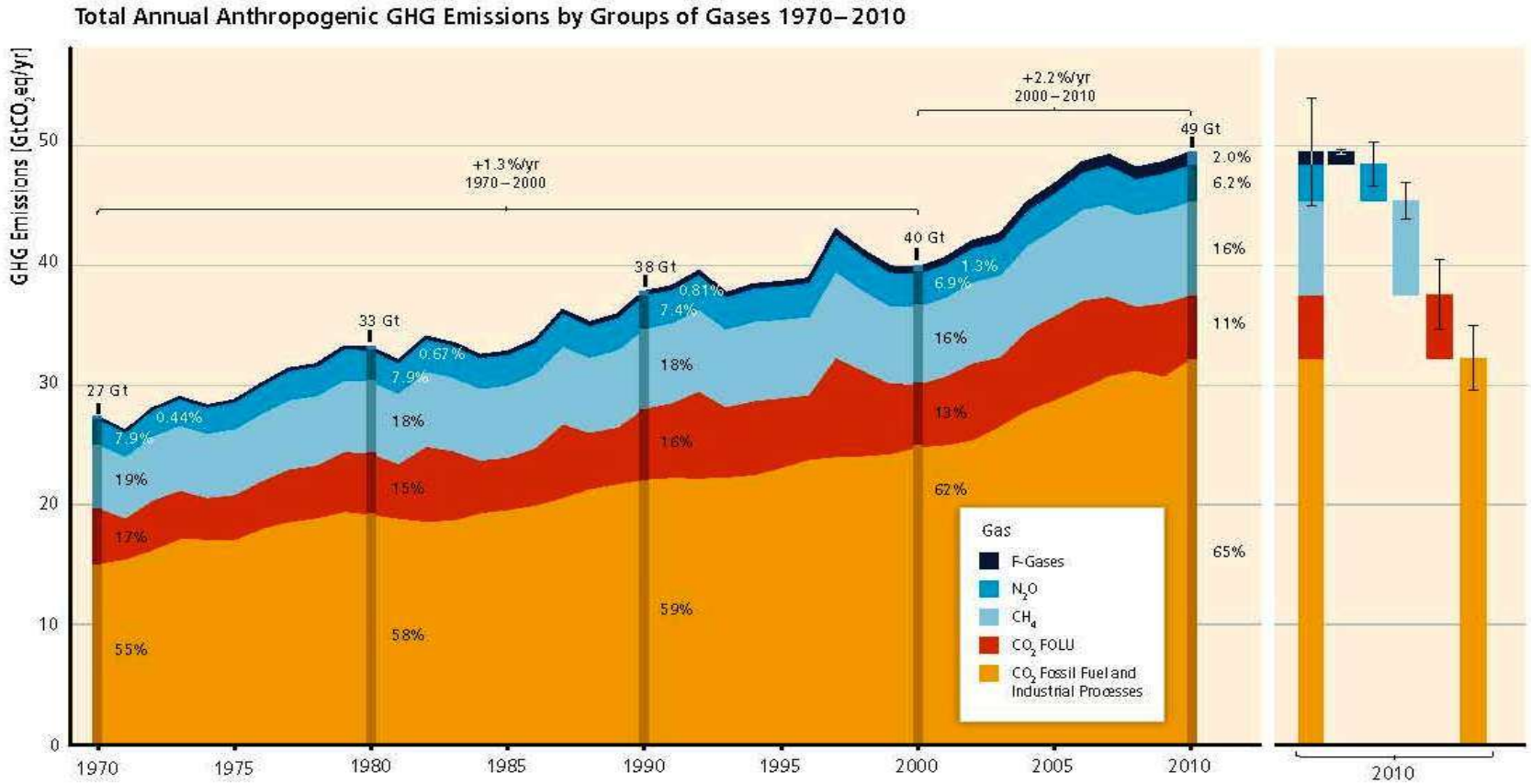


Figure SPM.1 | Total annual anthropogenic GHG emissions ($GtCO_2eq/yr$) by groups of gases 1970–2010: CO_2 from fossil fuel combustion and industrial processes; CO_2 from Forestry and Other Land Use (FOLU); methane (CH_4); nitrous oxide (N_2O); fluorinated gases[8] covered under the Kyoto Protocol (F-gases). At the right side of the figure GHG emissions in 2010 are shown again broken down into these components with the associated uncertainties (90% confidence interval) indicated by the error bars. Total anthropogenic GHG emissions uncertainties are derived from the individual gas estimates as described in Chapter 5 [5.2.3.6]. Global CO_2 emissions from fossil fuel combustion are known within 8% uncertainty (90% confidence interval). CO_2 emissions from FOLU have very large uncertainties attached in the order of ±50%. Uncertainty for global emissions of CH_4, N_2O and the F-gases has been estimated as 20%, 60% and 20%, respectively. 2010 was the most recent year for which emission statistics on all gases as well as assessment of uncertainties were essentially complete at the time of data cut-off for this report. Emissions are converted into CO_2-equivalents based on GWP_{100}[6] from the IPCC Second Assessment Report. The emission data from FOLU represents land-based CO_2 emissions from forest fires, peat fires and peat decay that approximate to net CO_2 flux from FOLU as described in Chapter 11 of this report. Average annual growth rate over different periods is highlighted with the brackets. [Figure 1.3, Figure TS.1]

Total CO2(e) Emissions in 2016 about 50 x 10^9 (Billion) Tonnes/Year.

Ref: IPCC Synthesis Report 2014 http://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_SPMcorr2.pdf

(EIA Emission Forecasts)

International Energy Outlook 2016

With Projections to 2040, May 2016

U.S. Energy Information Administration, Office of Energy Analysis

U.S. Department of Energy, Washington, DC 20585

(Extract from Pg. 5)

"World carbon dioxide emissions

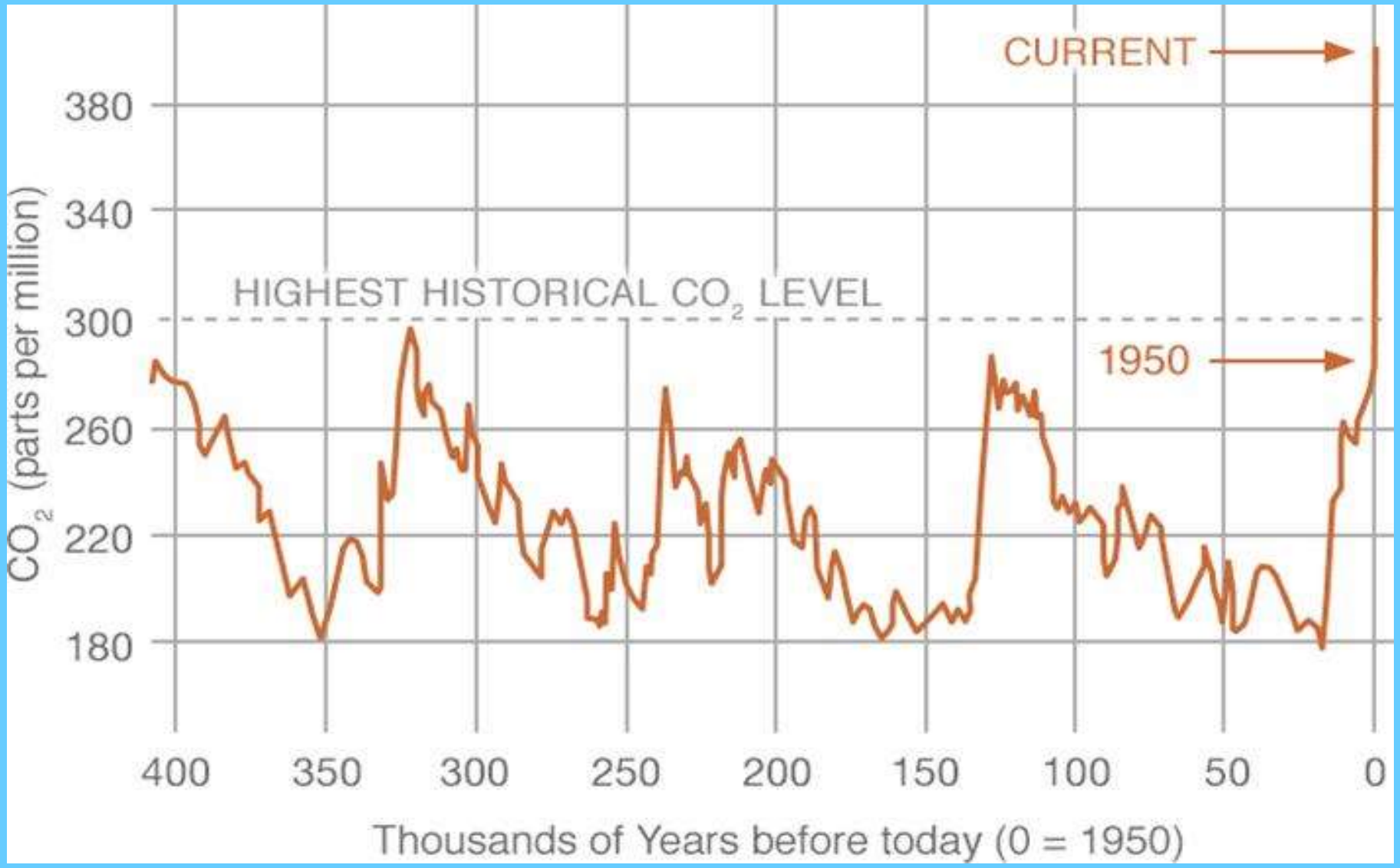
World energy-related CO2 emissions rise from 32.2 billion metric tons in 2012 to 35.6 billion metric tons in 2020 and to 43.2 billion metric tons in 2040 (in the IEO2016 Reference case) an increase of 34% over the projection period.

Much of the growth in emissions is attributed to developing non-OECD nations, many of which continue to rely heavily on fossil fuels to meet the fast-paced growth of energy demand."

Source: https://www.eia.gov/forecasts/ieo/pdf/0484(2016).pdf

(>400 ppm CO2 concentrations)

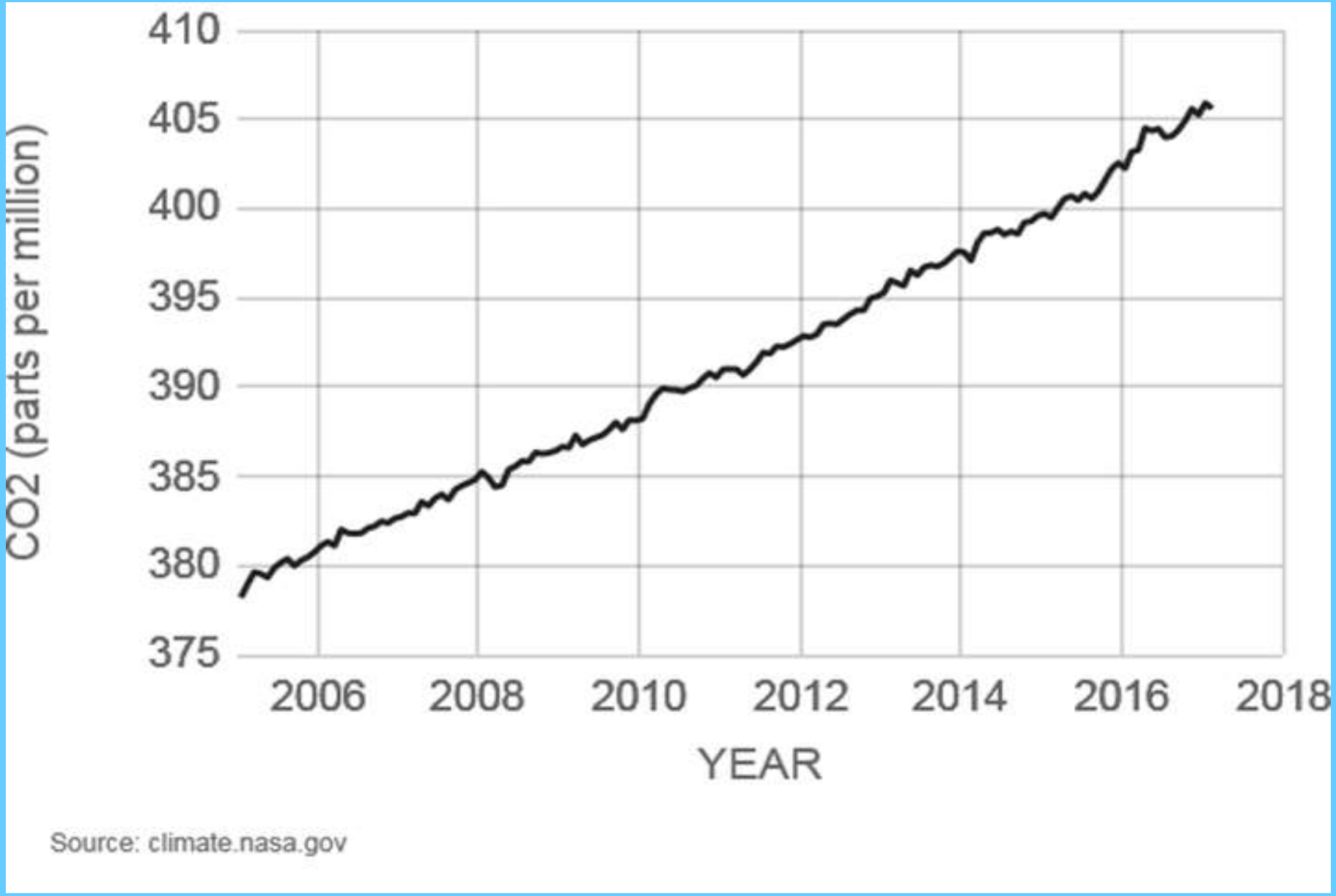
CO_2 Concentrations in Atmosphere (Feb'17 = 406 ppm)



This graph, based on the comparison of atmospheric samples contained in ice cores and more recent direct measurements, provides evidence that atmospheric CO_2 has increased since the Industrial Revolution.

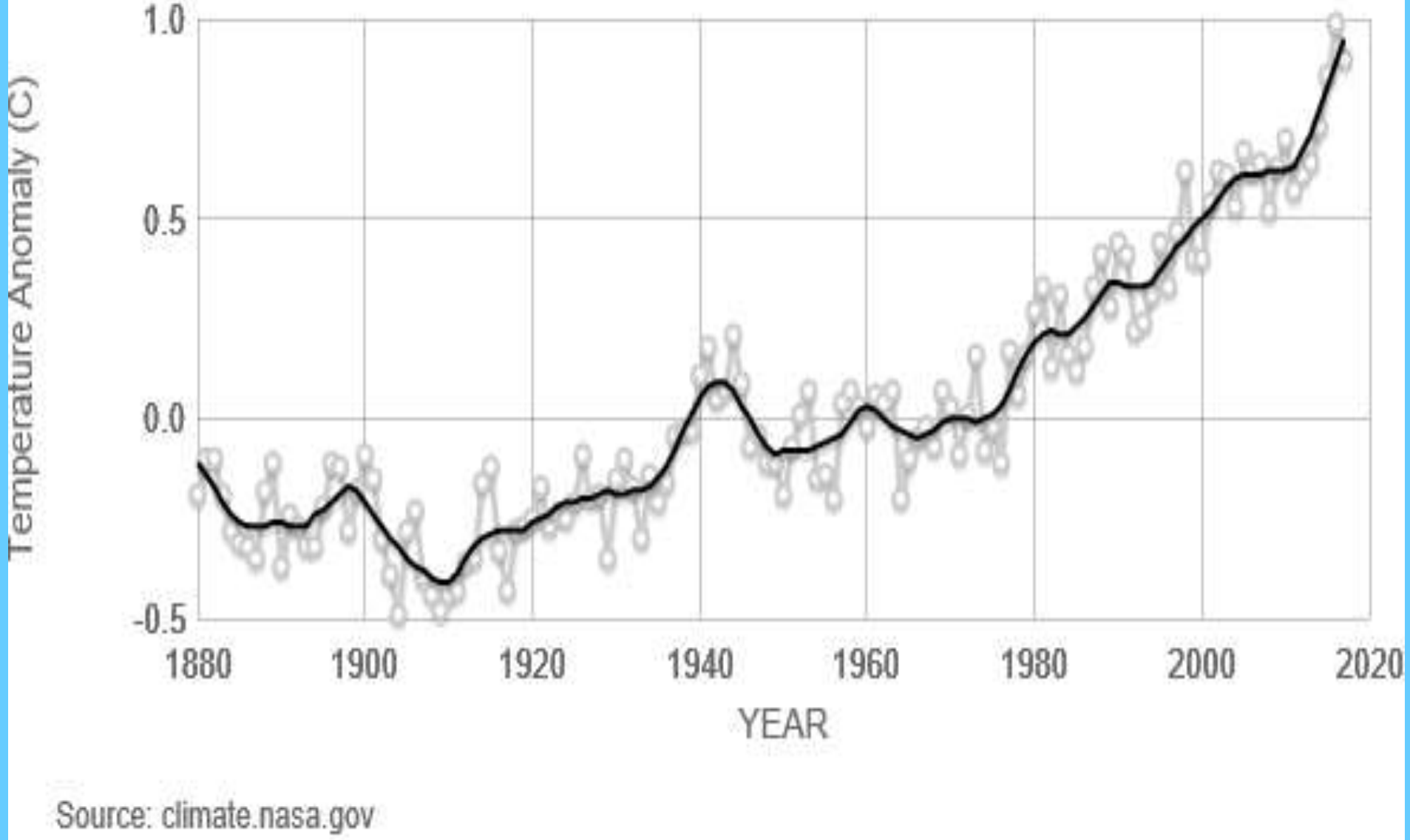
***(Source:** NASA & NOAA: https://climate.nasa.gov/vital-signs/carbon-dioxide/* *(Detailed CO2)*

CO_2 Concentrations in Atmosphere (Feb'17 = 406 ppm)



***(Source:** NASA & NOAA: https://climate.nasa.gov/vital-signs/carbon-dioxide/* *(Temp. Increase)*

Global Land/Ocean Temperature Changes



Source: *NASA's Goddard Institute for Space Studies (GISS). Credit: NASA/GISS* https://climate.nasa.gov/vital-signs/global-temperature/ ***(****IPCC)*

IPCC Climate Change Report – Impacts, Adaptation & Vulnerability 31 March 2014

- **2014 IPCC reports drawn up by hundreds of the world's leading Scientists,** tackled the more practical question "So, what does it mean for us?"

- **Reports come to some stark conclusions** that unless the world changes course immediately and dramatically, the fundamental systems that support human civilization are at risk.

- **Serious negative effects on food crops, water supplies, and human health,** plus global species loss, by 2100, even if ambitious action taken.

- **Virtually every corner of the globe is expected to suffer widespread impacts** by the end of the century.

- **Civil War Risks;** "Climate change can indirectly increase risks of violent conflicts in the form of civil war…."

Ref: http://ipcc-wg2.gov/AR5/images/uploads/IPCC_WG2AR5_SPM_Approved.pdf ***(****COP21 Dec'15)*

21st Conference of the Parties (COP21) Paris Dec'15

Highlights from the Agreement and the accompanying COP21 decision:

- **Reaffirm the goal** of limiting global temperature increase well below 2 degrees Celsius, while urging efforts to limit the increase to 1.5 degrees Celsius;
- **Establish binding commitments** by all parties to make "nationally determined contributions" (NDCs), and to pursue domestic measures aimed at achieving them;
- **Commit all countries to report regularly** on their emissions and "progress made in implementing and achieving" their NDCs, and to undergo international review;
- **Commit all countries to submit new NDCs every five years**, with the clear expectation that they will "represent a progression" beyond previous ones;

SOURCE: HTTP://WWW.C2ES.ORG/INTERNATIONAL/NEGOTIATIONS/COP21-PARIS/SUMMARY

(COP22)

COUNTRIES THAT JOINED THE PARIS CLIMATE AGREEMENT

SOURCE: UNFCCC **NOTE:** Denmark's agreement excludes Greenland. Map is updated as of May 31, 2017.

BUSINESS INSIDER

Emissions Gap & COP22 ~ Marrakech, Nov'16

- Average world ambient temperatures presently more than 0.8°C above pre-industrial temperatures.

- Earth's 2016 surface temperatures were the warmest since modern record keeping began in 1880, according to independent analyses by NASA and the National Oceanic and Atmospheric Administration (NOAA). 2017 was the second warmest on record and hotter than the third warmest 2015.

- According to a U.N. 'Emissions Gap Report' (3 Nov'16), it finds that the emissions level resulting from full implementation of all unconditional intended nationally determined contributions (INDCs) would lead to a temperature increase of 3.2°C before 2100.

Sources: https://www.nasa.gov/press-release/nasa-noaa-data-show-2016-warmest-year-on-record-globally and http://uneplive.unep.org/media/docs/theme/13/Emissions_Gap_Report_2016.pdf

(NASA & PERMAFROST)

NASA's Carbon in Arctic Reservoirs Vulnerability Experiment is probing deep into the frozen lands above the Arctic Circle in Alaska to measure emissions of the greenhouse gases CO_2 and methane from thawing permafrost - signals that may hold a key to Earth's climate future.

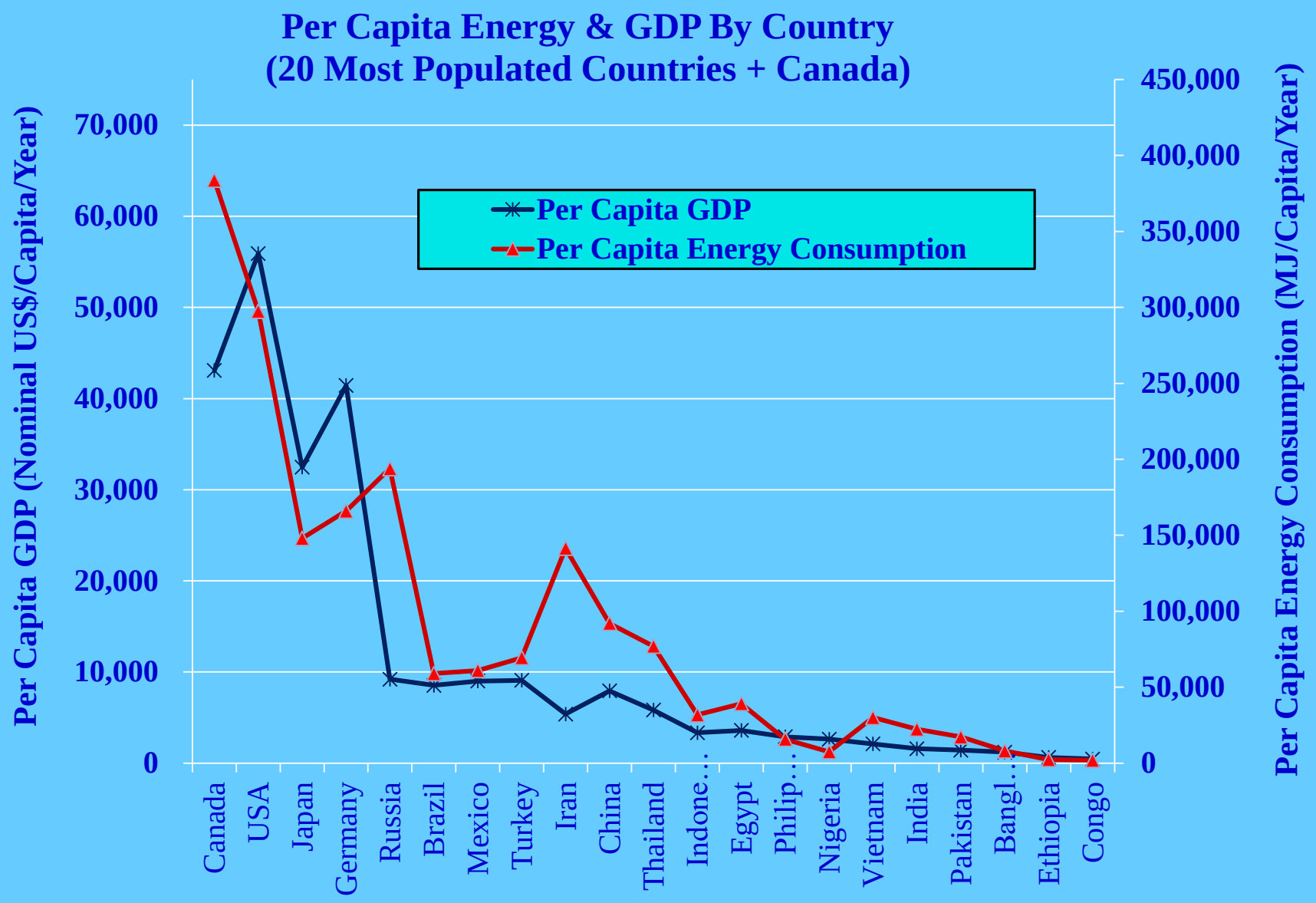
- ***"Over hundreds of millennia**, Arctic permafrost soils have accumulated vast stores of organic carbon - an estimated 1,400 to 1,850 petagrams* [billion metric tonnes] *of it.."*

- ***"Permafrost soils are warming even faster than Arctic air temperatures** - as much as 2.7 to 4.5 degrees Fahrenheit (1.5 to 2.5 degrees Celsius) in just the past 30 years." As they warm they give off GHGs (CO2 & Methane).*

***Ref:** NASA* **http://science.nasa.gov/missions/carve/, June 2013** (*Methane in North)*

Permafrost Methane

Source: http://i.dailymail.co.uk/i/pix/2014/08/06/article-2717938-204ED59000000578-215_634x424.jpg (Per Capita $ & MJ)



Sources: *https://www.bp.com/content/dam/bp/pdf/energy-economics/statistical-review-2016/bp-statistical-review-of-world-energy-2016-full-report.pdf and https://www.eia.gov/beta/international/data/browser/#/?pa=000000001&c=ruvvvvvfvtvnvv1urvvvvfvvvvvvfvvvou20evvvvvvvvvvnvvuvo&ct=0&vs=INTL.44-2-AFG-QBTU.A&ord=SA&cy=2013&vo=0&v=H&start=2013&end=2014 and http://data.worldbank.org/data-catalog/Population-ranking-table and http://data.worldbank.org/data-catalog/GDP-ranking-table .*

(Driving Forces)

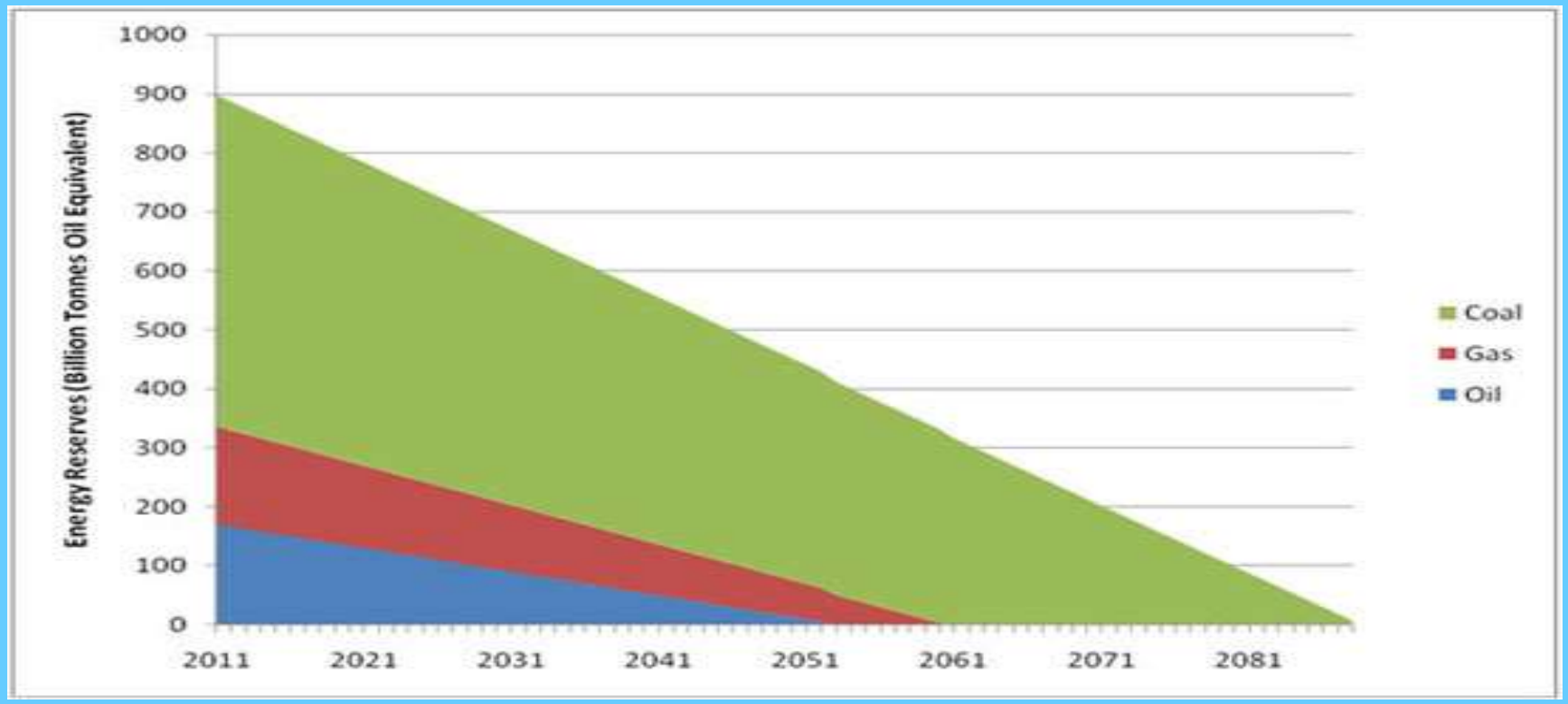
The Driving Forces & Trends:

- Significant Population Growth in the Developing World
- Significant Increase in Energy Consumption in the Developing World *(both Per Capita and Total Population)*
- Significant Increase in Greenhouse Gas Emissions in the Developing World (without major technical Energy “breakthroughs”)
- The triple "Whammy“ seems inevitable and predictable

(Possibly150 to 200 Years of Fossil Fuels)

World Fossil Fuel “Reserves"

Our World reserves of Fossil Fuels are finite – it is not a matter of **if** but **when** they will run out. So when will our fossil fuels run out?



However, the 5 billion who live in the “Have-Not” countries will double treble or quadruple their Per Capita Energy Consumption while their population increases to 8 billion before 2100. Consequently, fossil fuels will run out earlier rather than later (possibly 150 to 200 years).

•***Source: https://www.ecotricity.co.uk/our-green-energy/energy-independence/the-end-of-fossil-fuels***

(Sundance ~ 2,126 MW)

Sundance, TransAlta's 2,126 MW Coal-Fired Power Plant, Alberta

Ref: Trans Alta Photo

Life Cycle 20-Year "Horizon" Emissions re Coal ~1,000 kg CO2(e)/MWh *(Pakistan Oil Fired)*

Oil/HFO-Fired 135 MW Power Plant, Pakistan

Source: Southern Electric Co. Ltd., Pakistan.

Life Cycle, 20-Year "Horizon" Emissions HFO ~ 900 kg $CO2_{(e)}$ /MWh *(Combined Cycle Gas Fired)*

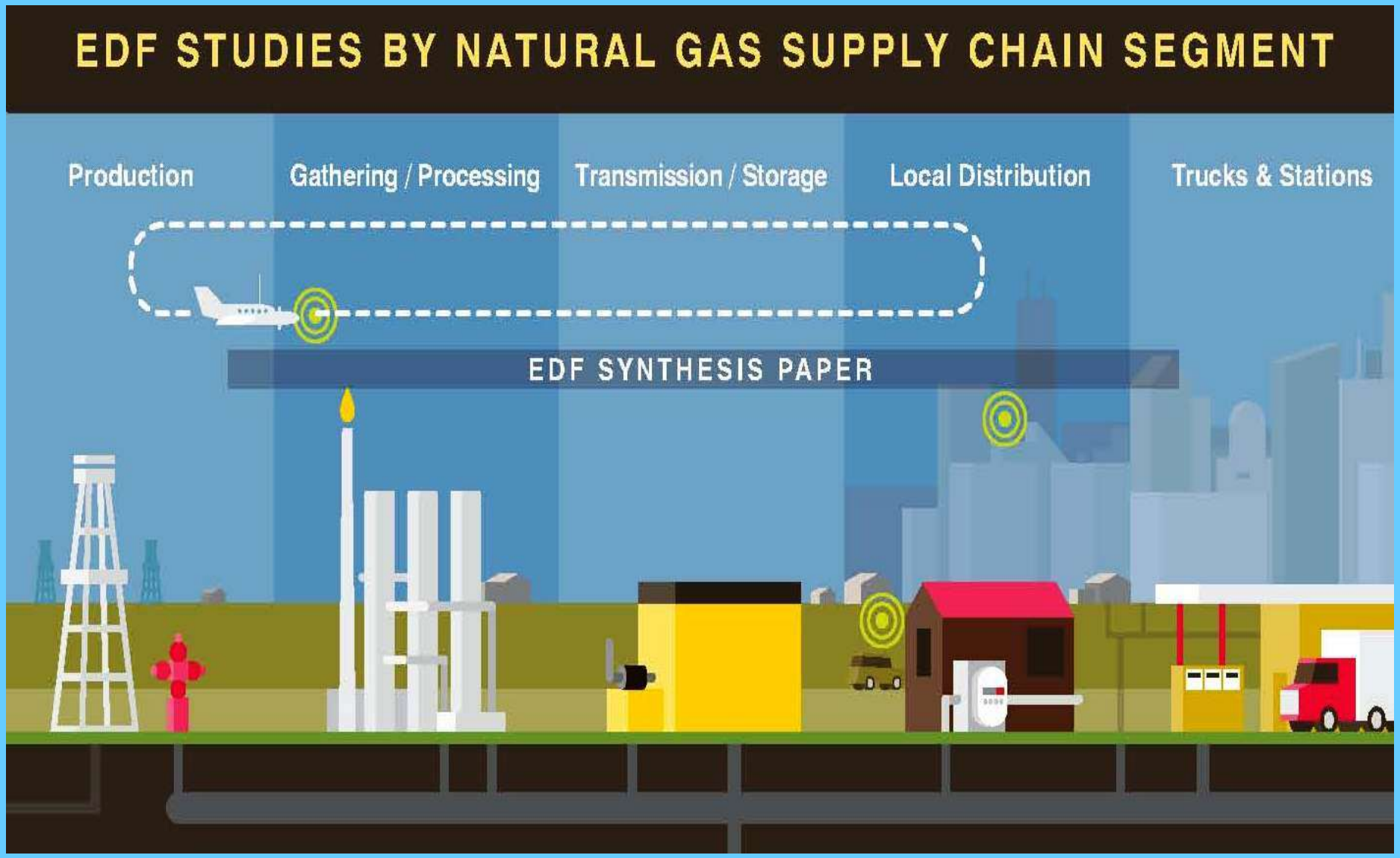
Claus C (Netherlands) 360 MW Gas-Fired Combined Cycle Plant

Ref: Alstom (http://www.alstom.com/power/gas-power/turnkey-power-plants/combined-cycle/ka26/)

Within the Fence Only, $CO_2(e)$ Emissions ~ 450 kg $CO_2(e)$/MWh.

Life Cycle, 20-Year "Horizon" Emissions from Gas (reasonably) ~ 800 to 1,200 kg $CO_2(e)$/MWh (GHGs / Methane)

Conventional & “Fracked” Shale Gas Systems



Ref: http://www.edf.org/sites/default/files/methane_studies_fact_sheet.pdf *(CO2(e) Conversion Factors)*

Greenhouse Gases & Conversion Factors To Obtain CO_2 Equivalents

Greenhouse Gas	Global Warming Potential [1] (GWP with c-cf) [2]	
	20 Years Time Horizon	100 Years Time Horizon
Carbon Dioxide (CO_2)	1	1
Methane (CH_4)	86	34
Nitrous Oxide (N_2O)	268	298
Chlorofluorocarbons (CFC-11)	7,020	5,350
Tetrafluoroethane (HFC-134a)	3,790	1,550
Carbon Tetraflouride (CF_4)	4,950	7,350

Note:

1. *Carbon dioxide has a GWP of exactly 1, since it is the baseline unit to which all other greenhouse gases are compared.*
2. *Climate–carbon feedback (c-cf).*

Source: ***http://www.climatechange2013.org/images/report/WG1AR5_Chapter08_FINAL.pdf*** ***(Gov. of Canada 25 Times Factor)***

“Government of Canada”

“Regulations Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (Upstream Oil and Gas Sector)”

“Executive Summary

Issues: Greenhouse gas (GHG) emissions are contributing to a global warming trend that is associated with climate change. Oil and gas facilities account for 26% of Canada’s total GHG emissions. These facilities are also Canada’s largest emitters of methane, a potent GHG with a global warming potential 25 times that of carbon dioxide (CO_2).”

Ref: http://gazette.gc.ca/rp-pr/p1/2017/2017-05-27/html/reg1-eng.html *(Not a “Bridging” Fossil Fuel)*

“Fracked” Shale Gas not a “Bridging” Fuel?

- Cornell University researchers issued their “milestone” paper on Fugitive Methane in 2011, yet it has taken more than 5 Years and the controversy still continues.

- There are hundreds of billions of U.S.$s and major National Energy Policy decisions in many countries riding on the outcome.

- It is unlikely that the “Dust” from the papers referenced above will settled soon as the total $CO_{2(e)}$ emissions from the use of Gas continue to be assessed.

- However, the indications are very clear that all the Fossil Fuels, when extracted, transported, distributed & burnt to produce electricity, emit Total $CO_{2(e)}$ of somewhere between 800 kgs/MWh and 1,200 kgs./MWh *(using IPCC 2013 AR5 ~ 20-Year “Horizon” factors).*

Ref: ***http://www.climatechange2013.org/images/report/WG1AR5_Chapter08_FINAL.pdf***

Observations on Fossil Fueled Energy Projects
(Coal, Oil, Nat. & Fracked Shale Gas)

CHALLENGES:

"The world has been in the Fossil Fuel Age since the early 1800s, and it is clear that we will not end the Fossil Fuel Age until and unless we find cost-effective, efficient and convenient human friendly and planet friendly alternate sources of power and energy, or until we exhaust the economically reachable fossil fuels in possibly 150 to 200 years." *(Ref: Stan Ridley UBC Seminars 2013)*

SOLUTIONS:

We Desperately Need Real "Breakthroughs" in Practical, Cost Effective, Efficient, Convenient and Planet Friendly Solutions including Energy Storage for Intermittent Energy, a new breed of "Walk Away Safe" Nuclear plants and Carbon Capture, use and/or Storage (CCS), to name just three items on my 2018 GW&CC Wish List.

(Renewables ~ Wind Water & Solar etc.)

Wind, Solar & Hydroelectric Renewables

Total Solar, Wind, & Water Power & Energy shining, blowing & flowing on the earth is enormous, and orders of magnitude greater than total world consumption. The challenge is how to harness this energy.
(Ref: Stan Ridley).

Ref: http://spectrum.ieee.org/energy/renewables/wind-water-and-solar-power-for-the-world *(Renewable Solutions)*

Renewable Energy Solutions?

The reality is that we will eventually have to rely almost entirely on Renewable Energy, Nuclear Energy, a little bit of CCS and hopefully new and presently unproven Energy sources, for almost all of our Global Energy consumption.

However, as presently configured and without major technological “breakthroughs”, none of these relatively “clean” technologies can be Scaled-Up Globally to make significant inroads into our present consumption of Fossil Fuels at 86%.

We need real technological “breakthroughs”.

(Revelstoke)

Hydroelectric Power Facilities (2,480 MW)

Ref: B.C. Hydro Revelstoke Hydroelectric Facilities *(Kaieteur)*

Kaieteur Falls, South America (741 ft Single Drop & 822 ft Total Drop; Niagara Falls is 173 ft High)

http://steve-powell.tripod.com/guyana/pictures/country/kaieteur/kaieteur.htm ***(No Swimming)***

Top Lip of Kaieteur Falls ~ Potaro River ~ Sign in Bottom Right Hand Reads "NO SWIMMING"

Photo. By Stan Ridley ***(Biomass Plant)***

Steven's Croft 44 MW Biomass Power Plant Scotland

Ref: http://www.mottmac.com/projects/?id=66058

(*Wind Turbine)*

On-Shore Wind Turbine/Generator Farm

6 ft Tall Man

Hub Height =80 m
~260 ft.

Ref: Milton Keynes Wind Farm - Vestas V90-2MW (http://www.flickr.com/photos/paul_burdon/5376454590/)

(Wind Capacity Factors)

Wind Power & Energy Generation

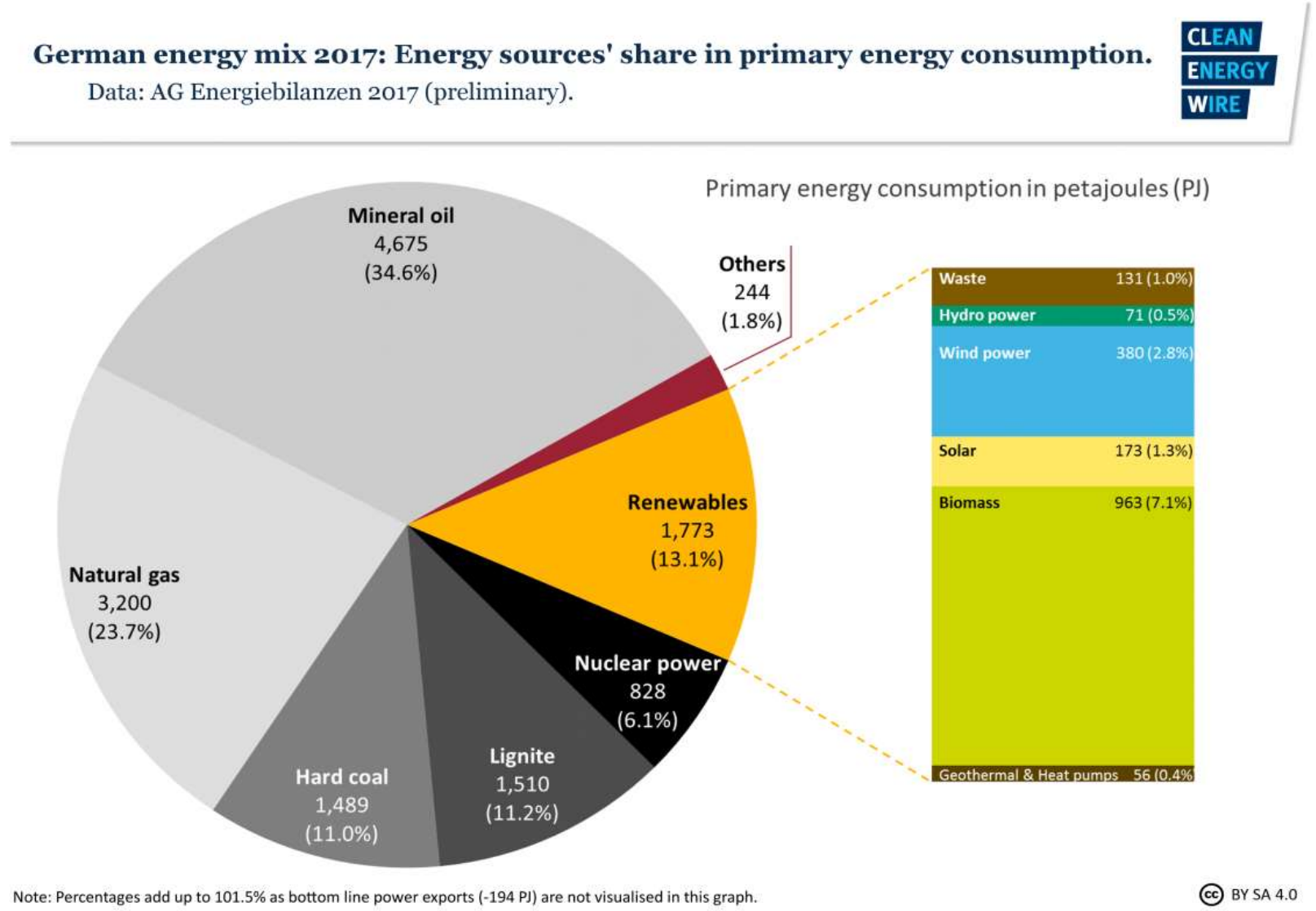
(Approx. 2016 data from Source shown below)

Country	Wind-Power Total Capacity to 31 Dec'16	Wind-Energy Total Generated in 2016	Wind Capacity Factors (Av. 2016)
	(MW)	(TWh/Year)	(%)
China	148,640	241	20%
United States	82,453	229	33%
Germany	49,534	77	19%
Spain	23,026	49	24%
India	28,700	45	19%
UK	15,695	38	29%
Canada	11,890	27	26%
France	11,670	21	22%
Italy	9,257	18	22%
Rest of World	88,124	215	30%
World Total for Wind	***468,989 MW*** ***(8% of World Electrical Capacity)***	***959 TWh*** ***(4% of World Electrical Energy & 1.6% of Total World Primary Energy)***	***25%*** ***Capacity Factor***

Source: https://www.bp.com/content/dam/bp/en/corporate/pdf/energy-economics/statistical-review-2017/bp-statistical-review-of-world-energy-2017-renewable-energy.pdf

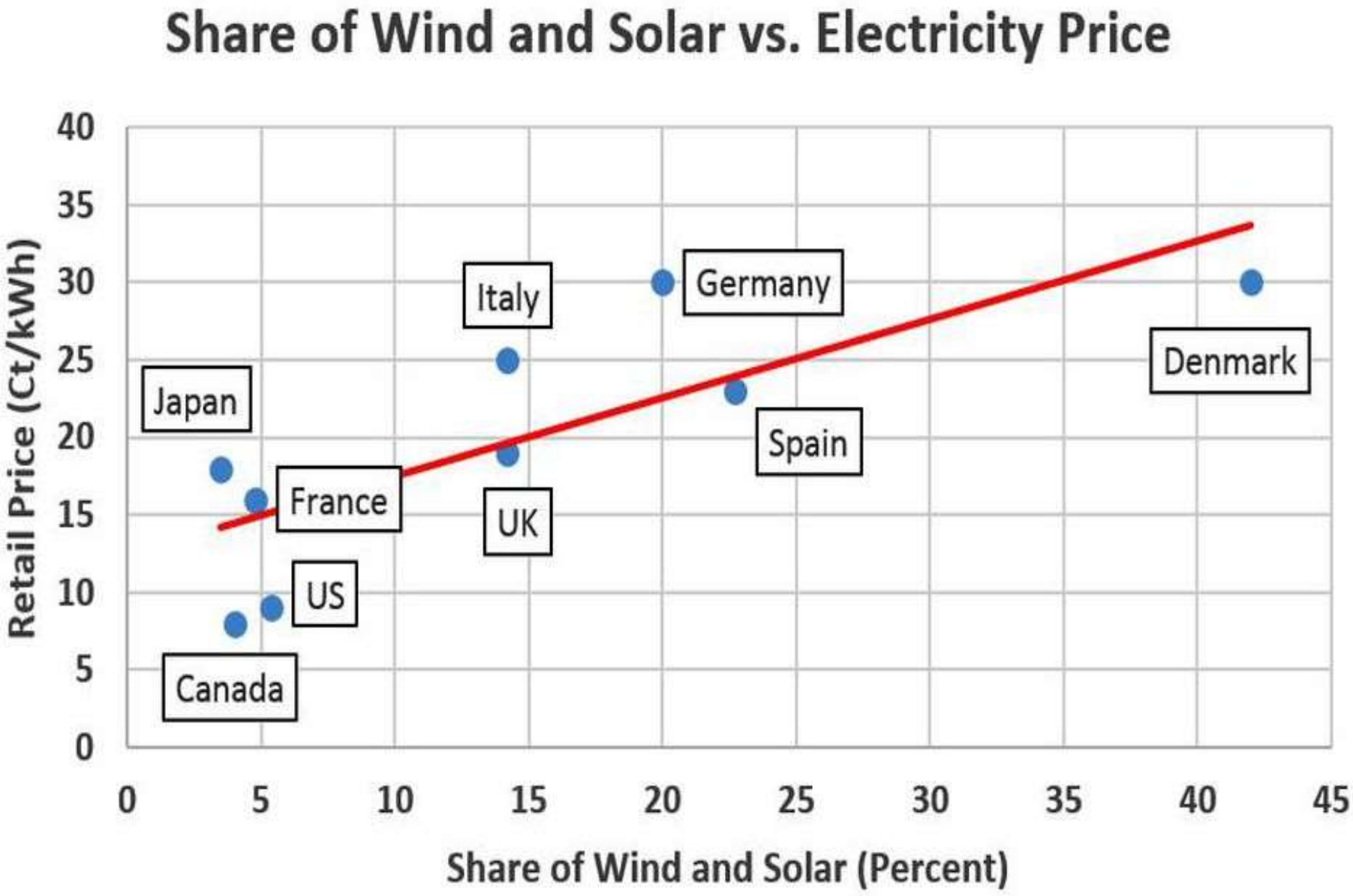
Note: Calculated Capacity Factors are based on the average installed Capacity (MW ~ between 1 Jan'16 & 31 Dec'16) (German Experience)

German 2017 Primary Energy Consumption



Total Fossil Fuels ~ 80%, All Renewables ~ 13%, Wind & Solar ~ 4%

Source: *https://www.cleanenergywire.org/factsheets/germanys-energy-consumption-and-power-mix-charts* *(Residential Costs)*



***Source*:** https://www.forbes.com/sites/uhenergy/2017/01/24the-cost-of-wind-and-solar-intermittency/#3b7a865a68de

(Observations on Renewables)

Observations on Non Despatchable Wind & Solar Energy Projects

We desperately need major R&D and "Breakthroughs" in energy storage for Wind & Solar energy generation and "Breakthroughs in managing and integrating renewable energy on our transmission grids/networks.

Please Don't use "green" land for Solar plants:

We should not be covering "green" land, that is growing or can grow $CO_{2(e)}$ absorbing plants and crops, with Solar panels & equipment.

The Atacama Desert in Chile or the Middle-East Deserts are fine for Solar panels.

(Nuclear)

Light Water Nuclear Power Plant

Source: TVA (http://web.ornl.gov/ornlhome/b_roll/casl.shtml)

(~ 450 Nuclear Plants Globally, & Nuclear Challenges)

Challenges with Present Global Fleet of Nuclear Plants

- **None of the existing commercial nuclear plants is "Walk-Away-Safe" &** there are other major challenges with the existing nuclear technologies:
- **Only about 5%** of the Uranium fuel's energy is used before removal from the Reactor.
- **Presently there is limited reprocessing** of "spent" nuclear fuel mainly because the recovered / reprocessed fuel tends to be a weapons grade material.
- **Reprocessing challenges need to be solved** to reprocess & reuse the "spent" fuel over and over until the resulting residue is very small and manageable in the long term.
- **Disposal remains a challenge** that needs to be addressed much more seriously.
- **We need a real "Breakthrough" in nuclear power.**

(Possible Nuclear Breakthroughs)

Possible "Breakthroughs" in Nuclear Energy

- **There are a number of new designs** on the drawing-board or in prototype state; an example is the proposed Transatomic plant [1 & 2]:
- **The molten salt reactor, has no fuel rods** but, instead, dissolves the nuclear fuel in liquid fluoride salt, to form a salt mixture, which is pumped in a loop with a reactor vessel at one end and a heat exchanger at the other
- **A drain system is plugged with solid frozen salt,** if the Plant loses power the plug melts and all the molten salt fuel drains by gravity to a safe cool storage tank.
- **Today's nuclear power plants extract about 5%** of the fuel's available energy, while Transatomic proposed plant is claimed to wrings out **more than 95%** of the fuel's available energy, and can also use the 95% of spent nuclear fuel.
- **We need dozens of such initiatives,** like dozens of "racehorses", in the hope that at least one comes home a winner ~ and quickly.
- **However, we need substantial funding,** not a few billion US$ but tens of billions of US$, in the hope that with resources and ingenuity we can find a "winner" [3].
- **Development, Prototype & Commercialization** take decades & time is running out.

Sources: *(1) http://www.newyorker.com/online/blogs/elements/2013/06/a-new-way-to-do-nuclear.html*
(2) http://www.transatomicpower.com/
(3) https://www.youtube.com/watch?v=eDCEjWNGv6Y (Levalized Long-Term Costs of Renewables)

Long Term Cost of Alternative Green Energy

Geothermal, Biomass, Nuclear and “discounted” intermittent Wind and Solar, are still quite expensive; relative to Fossil Fuels.

However, the Energy costs from Renewables (particularly Wind & Solar) are coming down rapidly.

GW&CC speaks to the very continuation of our Civilization; we can afford all of these technologies.

Price is not the main challenge ~ Intermittent Wind & Solar Energy Storage is the main challenge; we need major R&D and technical /operational “Breakthroughs”.

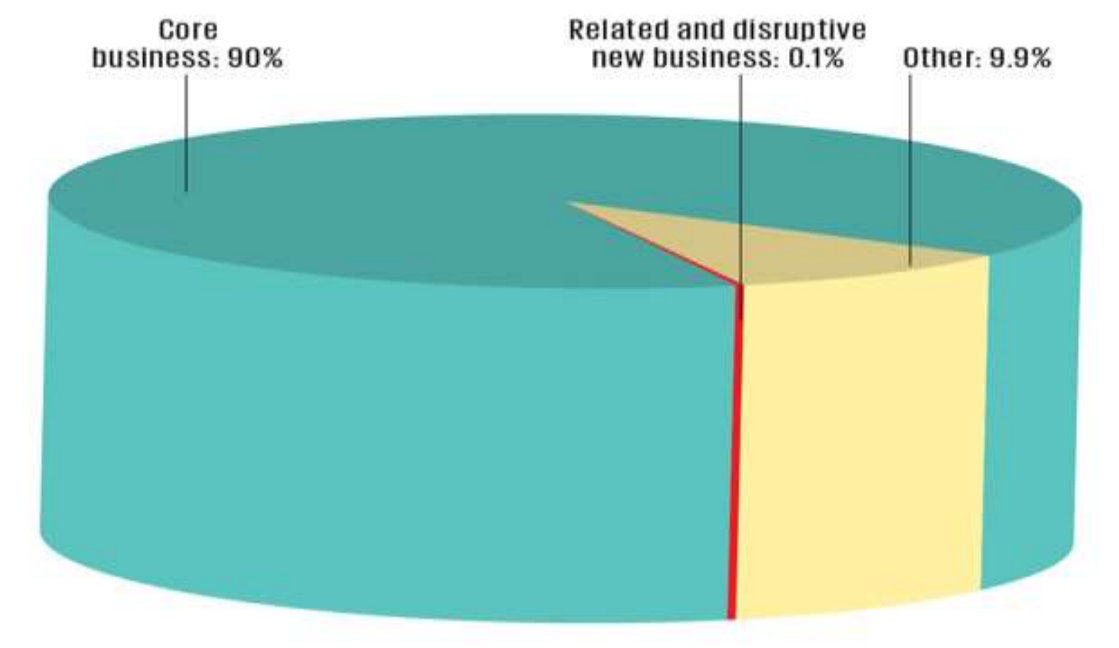
Source: ***International Energy Agency (IEA)*** : *https://www.iea.org/Textbase/npsum/ElecCost2015SUM.pdf* & Stan Ridley’s opinion.

(R&D $s)

Some Conclusions from Google Energy Engineers

2007: Google's boldest energy move was an effort known as RE<C, which aimed to develop renewable energy sources that would generate electricity more cheaply than coal-fired power plants do.

Nov 2014: Google Engineers conclude that trying to combat climate change exclusively with today's renewable energy technologies simply won't work; we need a fundamentally different approach.



Today In the United States, the vast bulk of funding for energy R&D goes to established technologies. Essentially no money (0.1%) is allocated to related and potentially disruptive technologies, and about 10 percent is spent on projects that don't seek to produce economically competitive energy.

Source: http://spectrum.ieee.org/energy/renewables/what-it-would-really-take-to-reverse-climate-change

Note: *"potentially disruptive technologies"* are new breakthrough technologies that could replace and/or displace fossil fuel consumption/technologies and are Planet and human friendly.

(*Some Overall Conclusions)*

Some Conclusions

In short we:

Have a Global Warming & Climate Change (GW&CC) crisis, caused mainly by manmade GHG emissions, that could end our Civilization in short order.

The world will not wean itself off of Fossil Fuels without cost effective, efficient and convenient alternatives.

Without real technological "breakthroughs", we effectively have no viable solutions to make a significant difference.

We are spending minute amounts on doing the desperately needed Power & Energy R&D to find real breakthrough solutions, for storage and efficient use of intermittent Energy, a new breed of safe & efficient Nuclear plants and CCS, to name just 3 items on a short GW&CC "wish list".

Globally more than US$ 1 trillion/year is urgently needed for Power & Energy R&D. Canada's portion would be US$20 billion/year and the US portion would be US$240 billion **(P.S. the US spends between US$600 and US$800 billion per year on its military and wars etc.).**

Canada's Mark Carney, *(Governor of Bank of England),* recently suggested the need for US$ 5 to US$7 trillion/year Globally for carbon reduction commitments *(see Ref.1 below).*

(Ref.1: Financial Post 15 July'16: http://business.financialpost.com/investing/climate-change-initiatives-a-7-trillion-funding-opportunity-for-capital-markets-carney).

Social and Political Perspectives

- **Politicians Follow the Votes**; they need to get re-elected and, constrained by the Voters, are unlikely to make the "hard" choices and decisions. *(e.g. Australia's removal of nominal CO2(e) Tax)*
- **Private (for-profit) Sector Companies Follow the Money**, and consequently are focused on the principal objectives of maximizing profits. *(VW Example re CO2(e) emission reporting "fix")*
- **Universities, Environmental Groups and Agencies like IPCC & NASA and other quasi "Independent" groups, are possible "Coalitions of the Willing, Capable & Independent"**
- **"Breakthroughs":** We desperately need real & viable "Breakthrough" solutions that are as efficient, reasonably inexpensive and as convenient as Fossil Fuels, and are also human & Planet friendly.
- **Problems are mainly Social & Political Challenges**

(Possible Ways Forward)

Possible Ways Forward

- **We vitally need significant funding** for a lot more research into areas that have a “fighting chance” of solving the Global Warming challenge, before launching into “flavour of the year” projects.

- **Our Coalition needs to urgently convince the Politicians** to stop subsidizing areas & facilities that clearly won’t help significantly.

- **Hope that we can find solutions that work** in time to turn our good ship “Earth’s Environment” before it ends up on the “Rocks”.

- **We need to clearly understand** that our ship will take 20 to 30 Years to start responding significantly to changes we make today.

- **Like the start of the Fossil Fuel Age, the New Power & Energy Age,** will generate enormous wealth while solving the Global Warming & Climate Change crisis (I hope).

Giant luxury cruise ship Crystal Serenity makes historic voyage in melting Arctic

Mark Thiessen, The Associated Press, 12 September 2016

Source: http://news.nationalpost.com/life/travel/giant-luxury-cruise-ship-crystal-serenity-makes-historic-voyage-in-melting-arctic

Challenges we dare not deny.

(The World)

“This is the only home we have”

Photo Source: http://www.geography4kids.com/extras/dtop_space/moonearth.html

Comments & Questions

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! Thank You !