



North America | Europe | Asia-Pacific

What Investors Need to Know About Technology and Climate Change: The Race of Our Lives

April 11, 2018



Jeremy Grantham

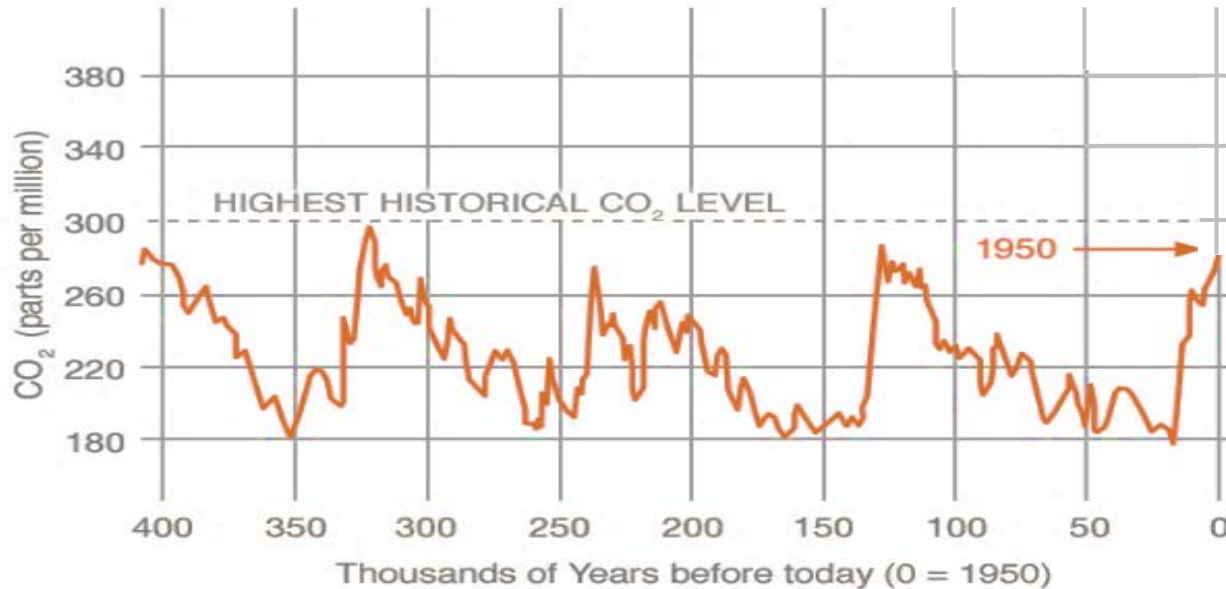
Mr. Grantham co-founded GMO in 1977 and is a member of GMO's Asset Allocation team, serving as the firm's chief investment strategist. He is a member of the GMO Board of Directors and has also served on the investment boards of several non-profit organizations. Prior to GMO's founding, Mr. Grantham was co-founder of Batterymarch Financial Management in 1969 where he recommended commercial indexing in 1971, one of several claims to being first. He began his investment career as an economist with Royal Dutch Shell. Mr. Grantham earned his undergraduate degree from the University of Sheffield (U.K.) and an M.B.A. from Harvard Business School. He is a member of the Academy of Arts and Sciences, holds a CBE from the UK and is a recipient of the Carnegie Medal for Philanthropy.

The Race of Our Lives: Climate Change Accelerates

Global Greenhouse Gas Oscillates... Until...

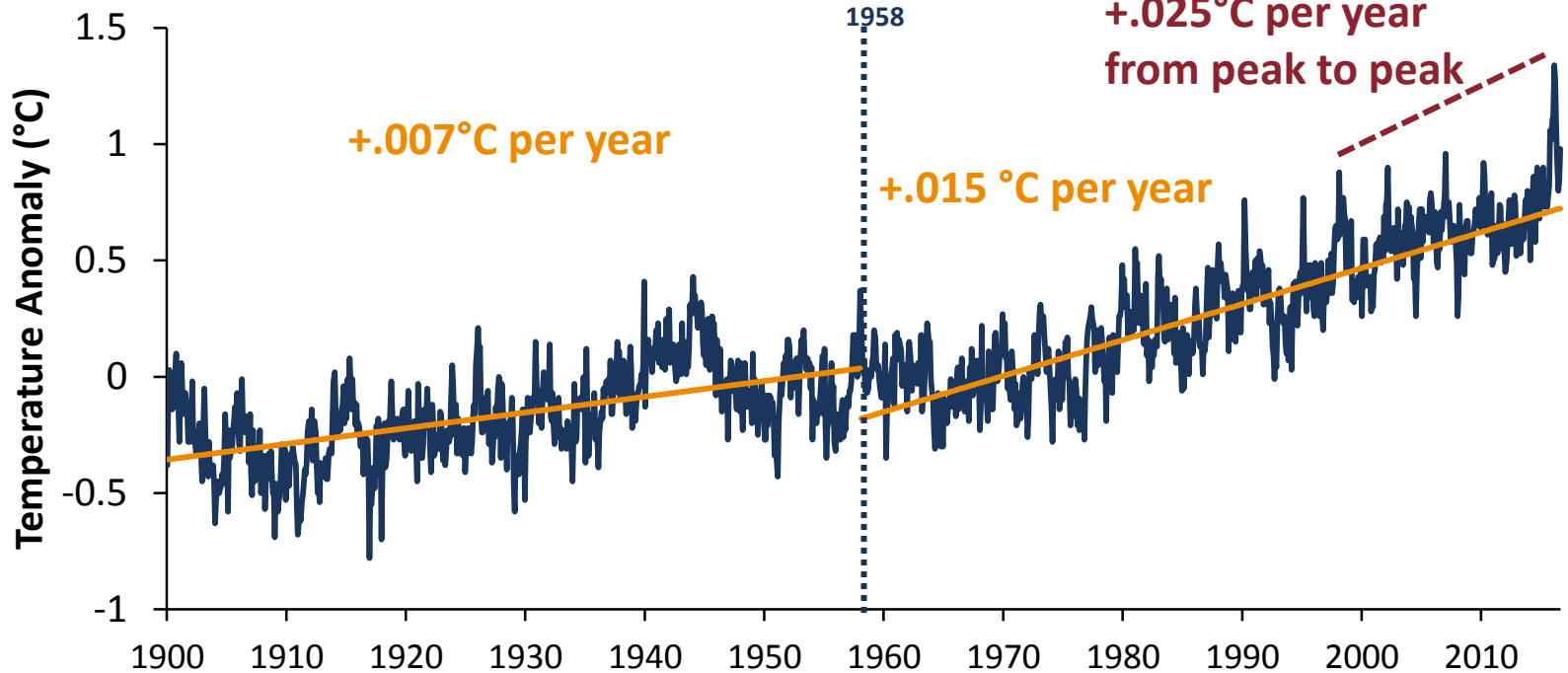
Historical CO₂ Levels

Proxy (Indirect) Measurements



Source: Reconstruction from ice cores
Credit: NOAA

Surface Temperatures: Not Just Rising but Accelerating

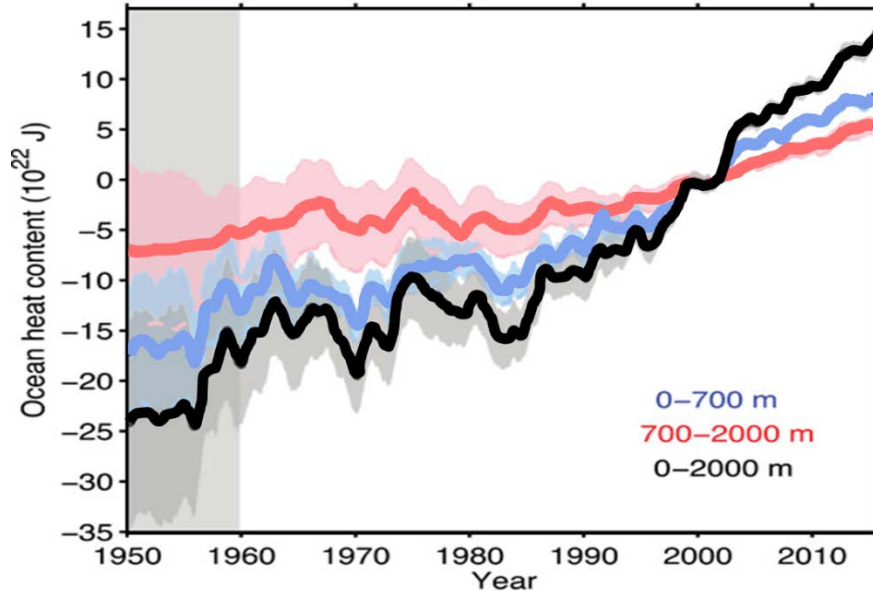


As of 8/31/16

Source: NASA Goddard Institute for Space Studies

Ocean Temperatures Also Accelerating

Ocean Heat Content (in Joules)



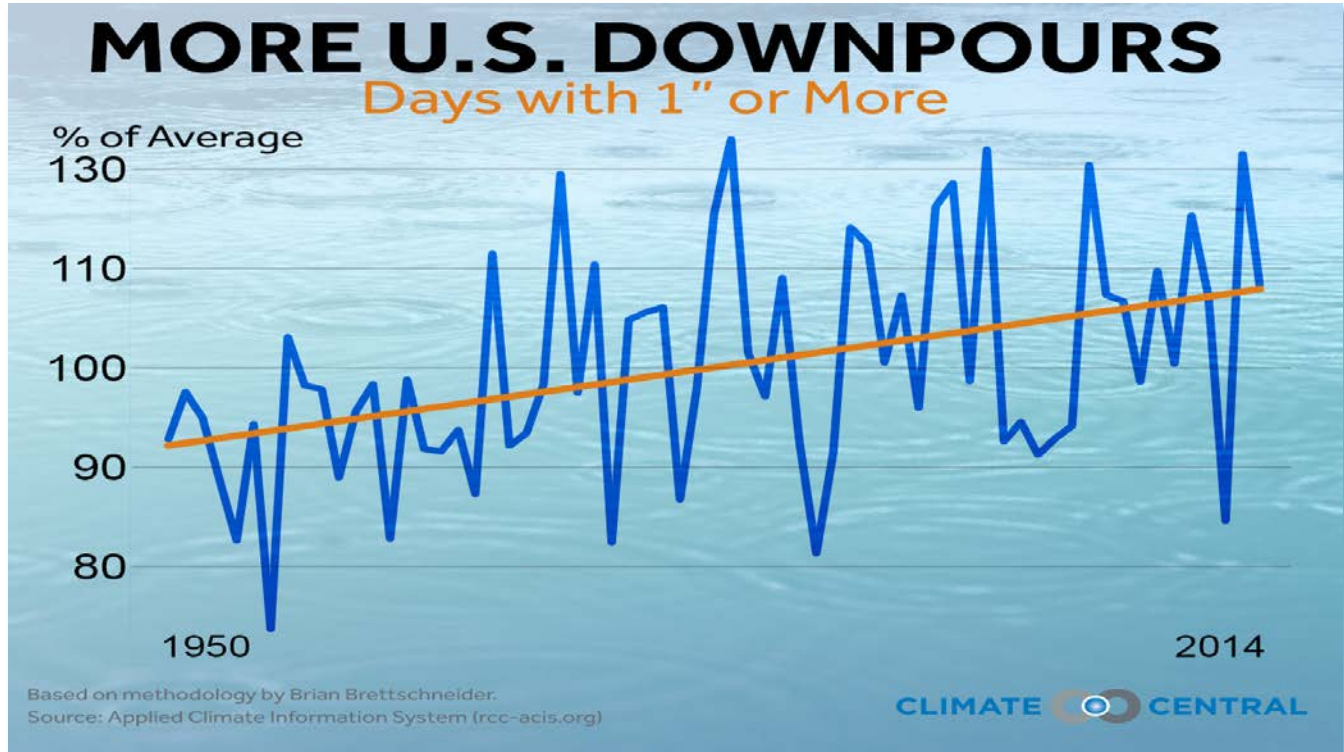
0 – 2000 M

1950 – 1990 = 37 units/year

1990 – 2016 = 99 units/year

Source: "Improved Estimates of Ocean Heat Content from 1960 to 2015", Cheng et al, *Science Advances*

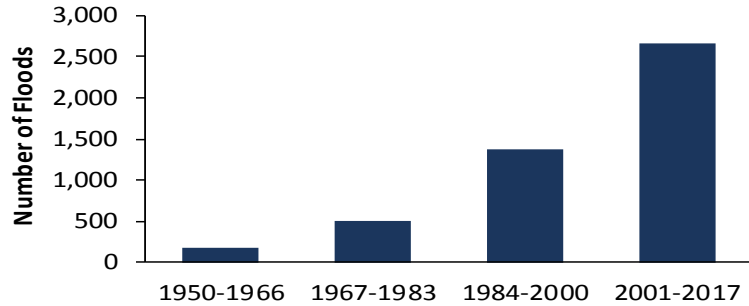
With Consequences!



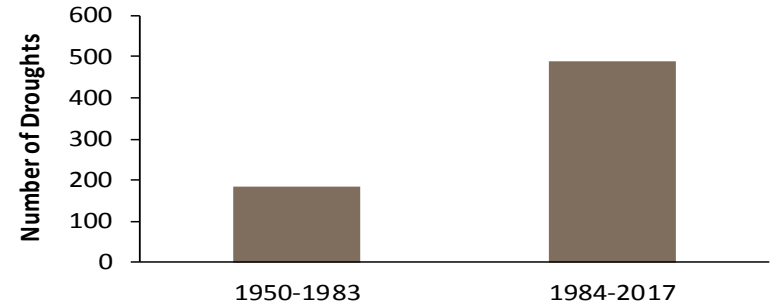
Serious, Widespread Consequences

Global extreme weather events have been on the rise

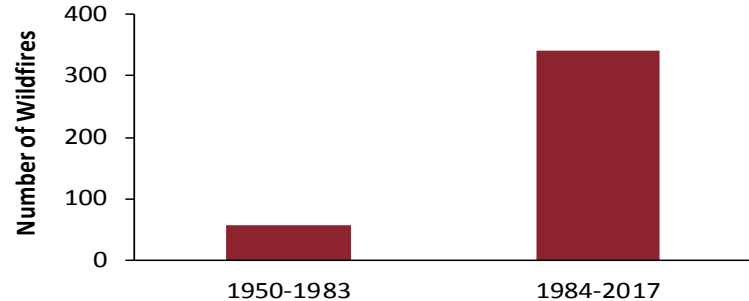
Floods



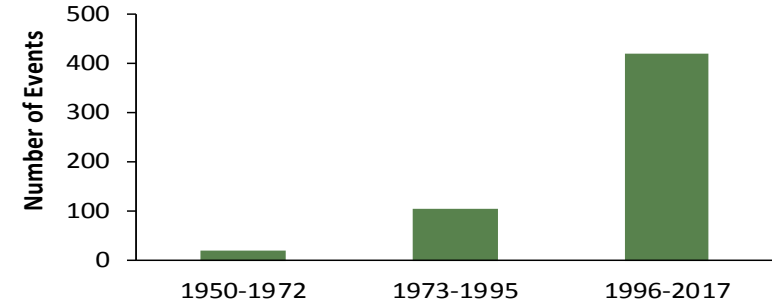
Droughts



Wildfires



Extreme Temperature Events



Source: HSBC

**Climate Change:
But Greener Technologies Also Accelerate**

Resulting in De-Carbonizing the Economy

From the Horse's Mouth

Alternative energy will crush fossil fuels – on cost!

“Without incentives, wind is going to be a \$0.02 or \$0.03 product early in the next decade. Battery storage will be \$0.01 on top of that. And when you look at (...) coal and nuclear, today, operating costs are around \$0.03. New wind and new solar, without incentives and combined with storage, are going to be cheaper than the operating cost of coal and nuclear in the next decade. That is going to totally transform this industry.

— James Robo, 06/22/2017

CEO of NextEra Energy

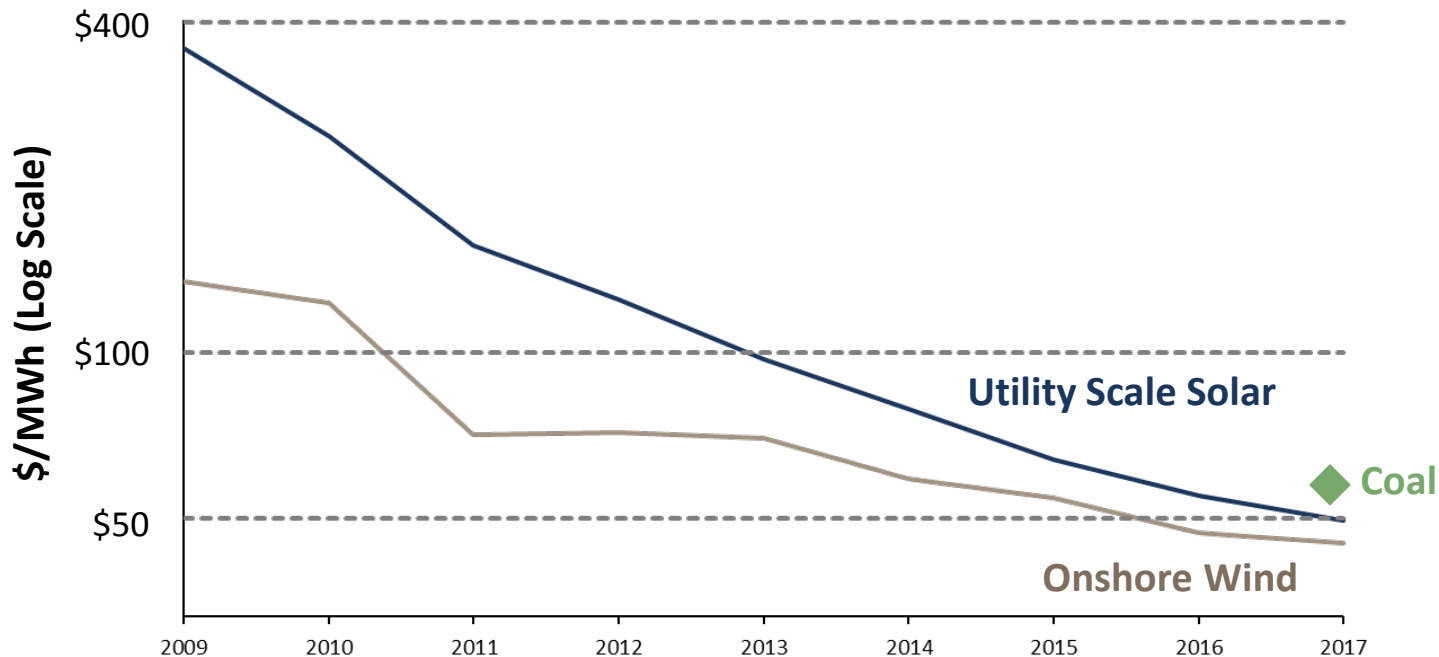
Hot Off the Press: Renewable Energy Proposals for Excel Corporation Colorado

- 350 Proposals for wind and solar, both with battery storage for 2023
- Median price \$21/MWH for wind plus storage
\$36 for solar plus storage
- Storage bids \$3 – \$7 down from \$15/MWH for Arizona Utility in May 2017

As Costs Continue to Drop for Wind and Solar, We Have Reached an Inflection Point

When this exhibit was first done, the title said "Will Reach"

Unsubsidized Levelized Cost of Energy over Time

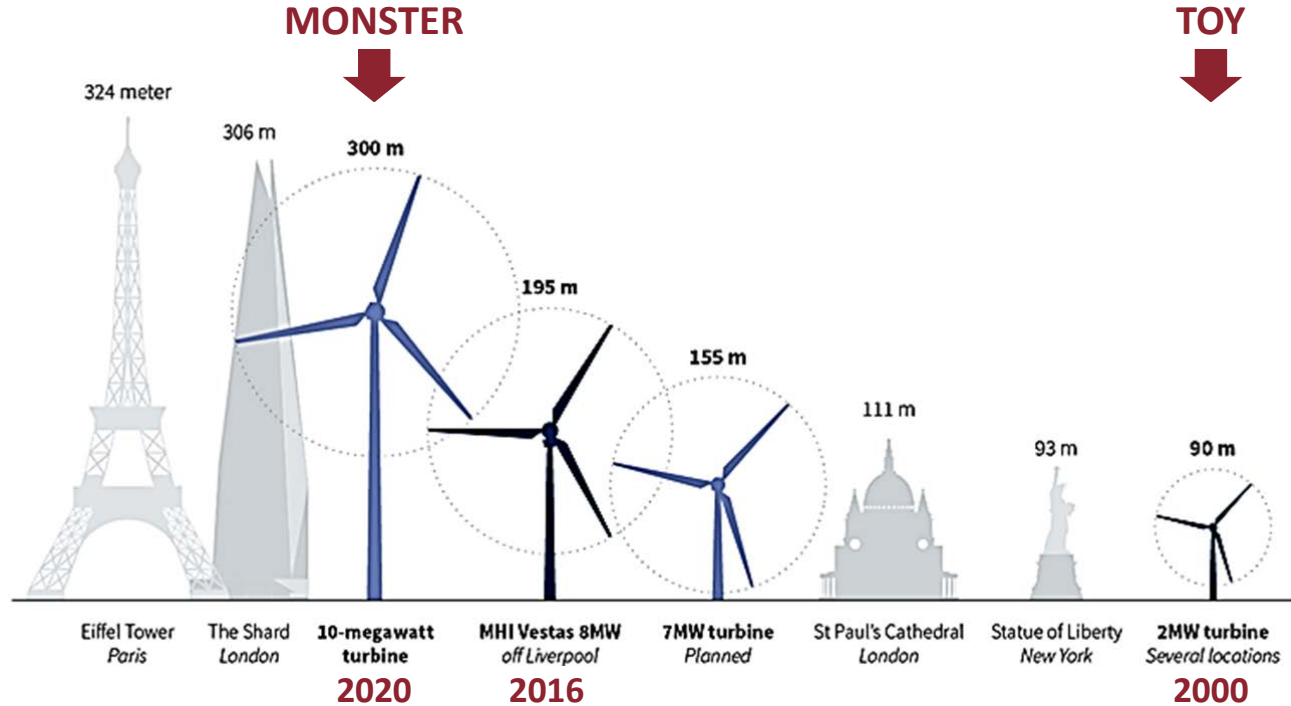


As of 12/31/16

Source: Lazard, SNL 2017, as cited by Carbon Tracker Initiative, No Country for Coal Gen (2017)

Giant Wind Turbines Illustrate The Speed of Change

Wind is becoming a powerful source of energy

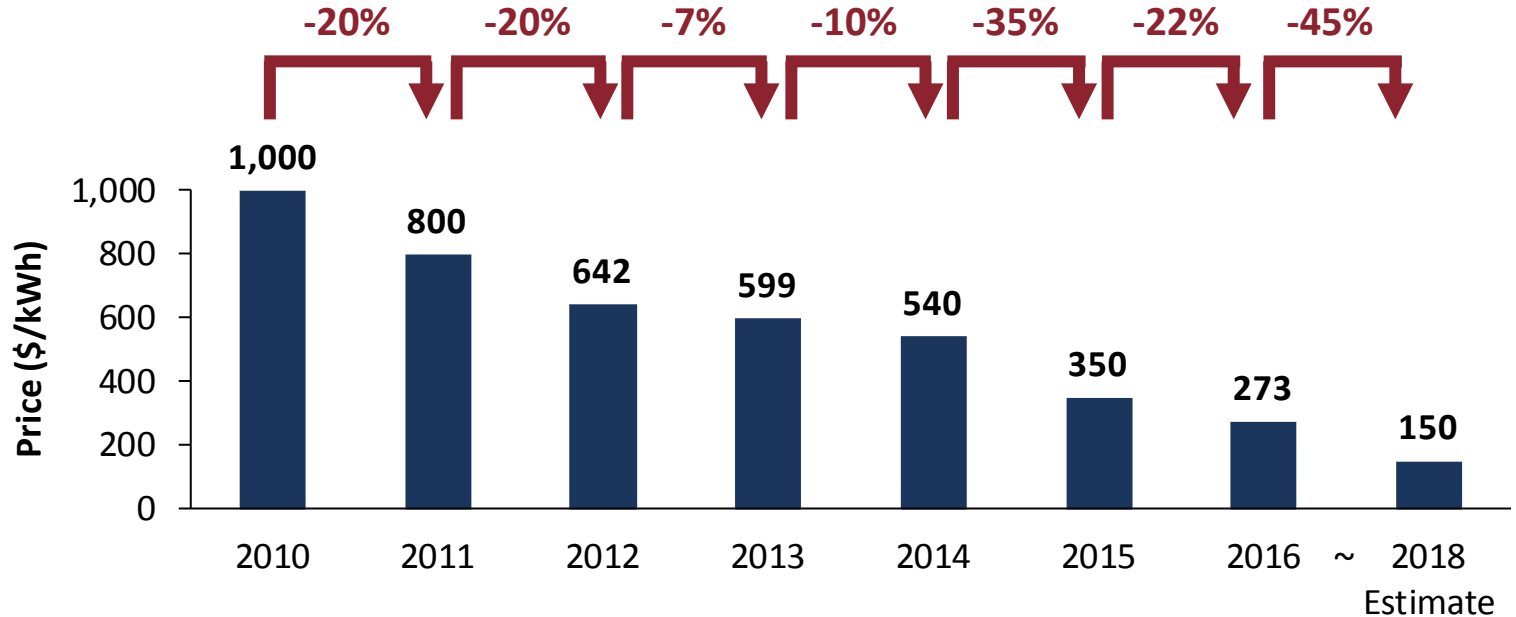


As of 13/06/17

Source: Reuters, Dong Energy UK, Nextwind Inc.

Battery Costs Continue to Drop as Well

Lithium-ion Battery Pack Prices

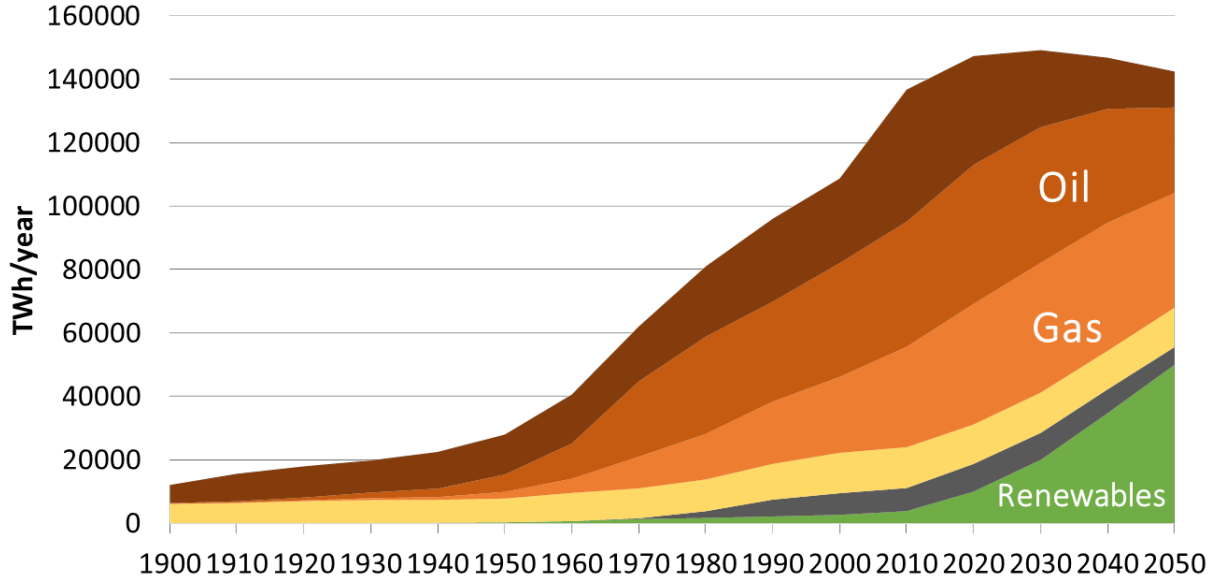


Source: Bloomberg New Energy Finance

Energy to Peak, Renewables to Grow...

But fossil fuels still 50% by 2050

World Annual Primary Energy Consumption by Source (1800-2010)



As of 09/30/17

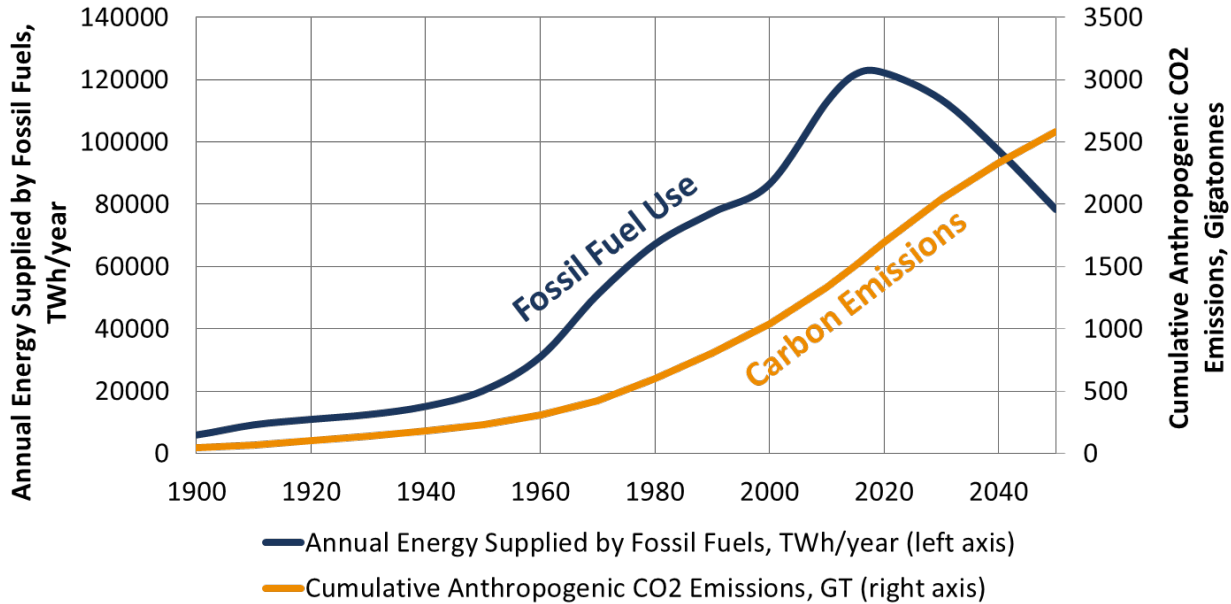
Data from 2010-2050 is estimated or forecast

Source: DNV GL, OurWorldInData.org, Vaclav Smil

■ Renewables ■ Nuclear ■ Biomass ■ Gas ■ Oil ■ Coal

But Climate Change Will Not Have Been Stopped

Annual Energy Supplied by Fossil Fuels, and Cumulative Total Human CO2 Emissions



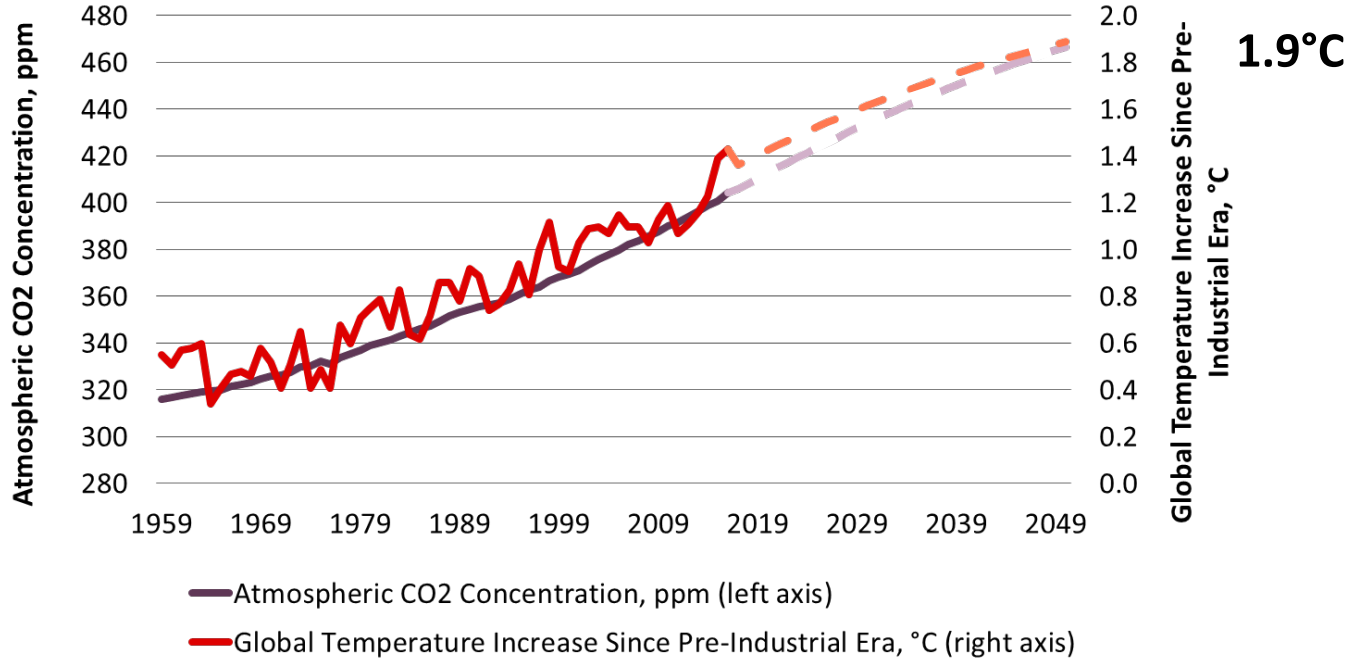
As of 09/30/17

Data from 2015-2050 is estimated or forecast

Source: DNV GL, OurWorldInData.org, Vaclav Smil, Carbon Dioxide Information Analysis Centre

Prepare Yourselves: 2° C, Here We Come!

Atmospheric CO2 Concentration and Temperature Increase since Pre-Industrial Era



As of 09/30/17

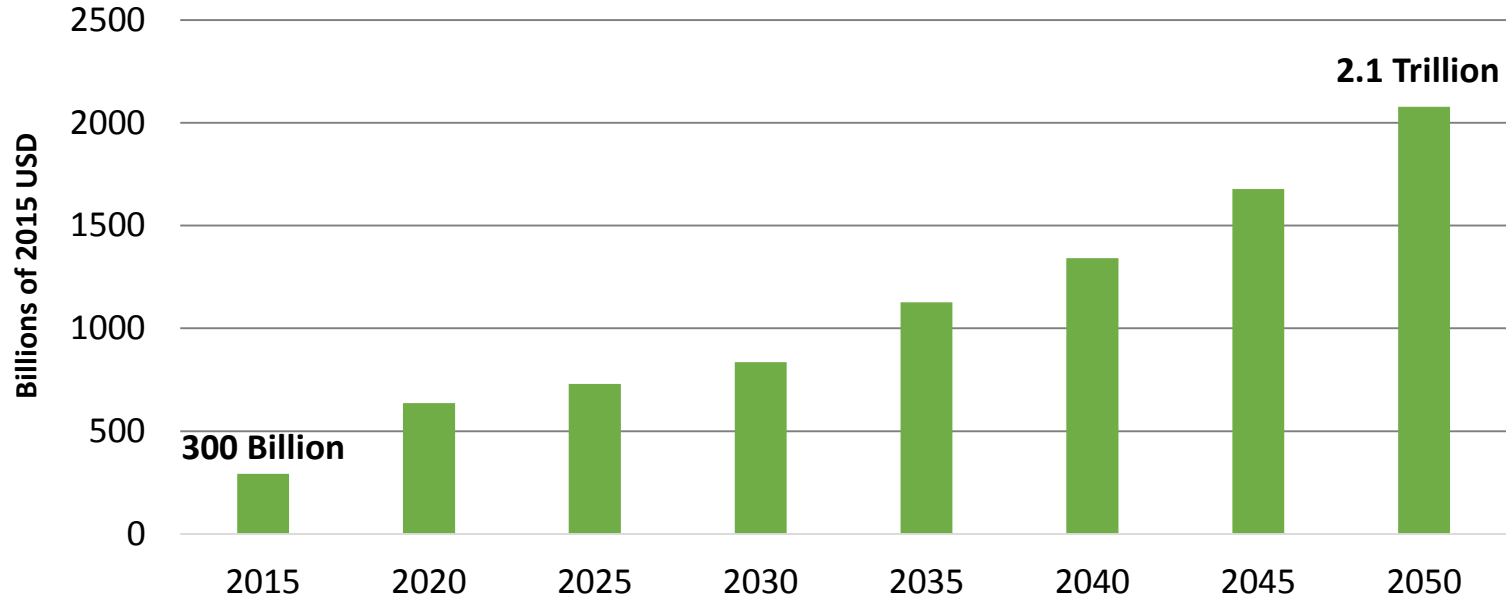
Data from 2016-2050 is estimated or forecast

Source: DNV GL, National Oceanic and Atmospheric Administration

Portfolios Must Prepare For Change Too

(The biggest transformation since the introduction of oil)

Annual Global Renewable Energy Capex (billions of 2015 USD)



As of 09/30/17

Data from 2015-2050 is estimated or forecast

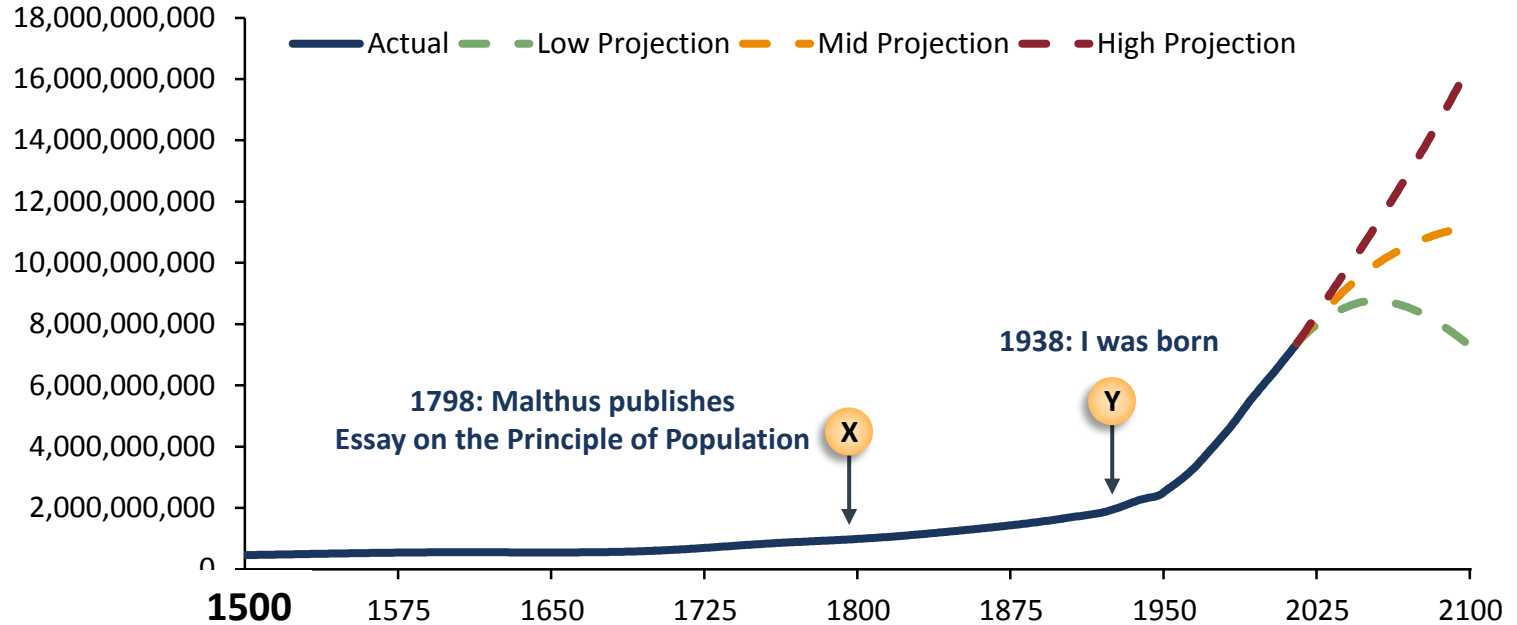
Source: DNV GL

Climate Change: But Now the Terrible News, Feeding the 12 Billion

The impact on food sufficiency of:

- population growth (plus increasing wealth)*
- climate change*
- soil erosion (and many related factors)*

World Population Projections: 2000-2100

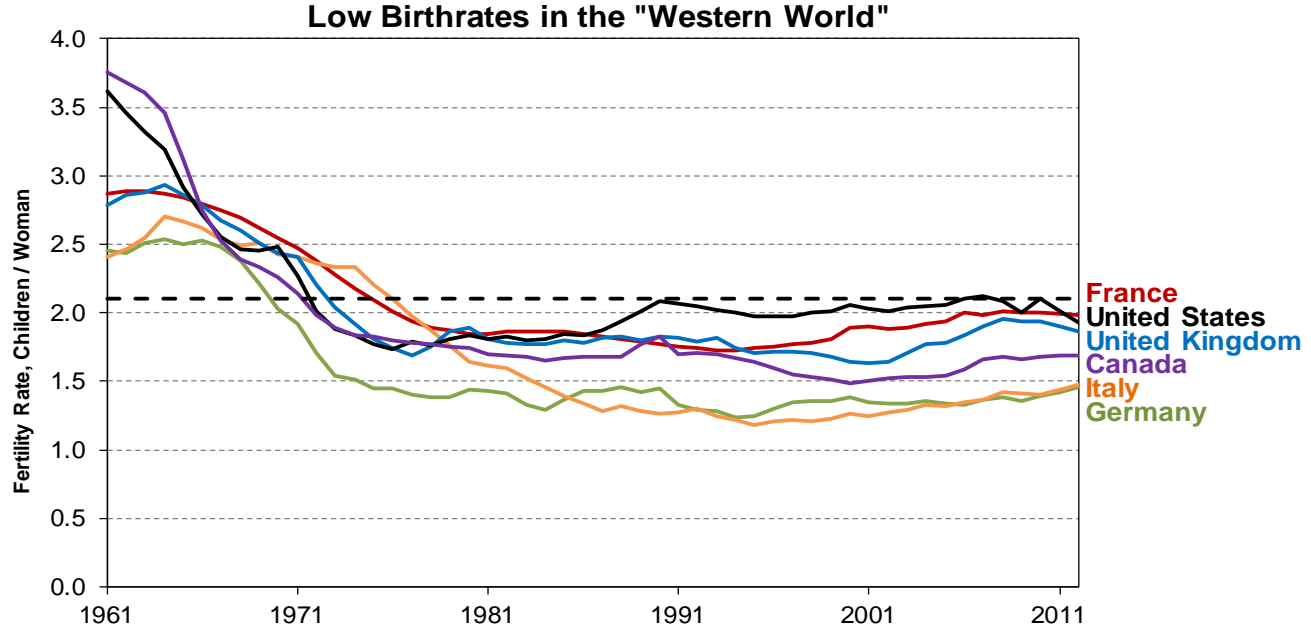


As of 1/25/18

Source: UN World Population Prospects

Our Last Best Hope: Fertility Rates Drop

Beyond the wildest dreams of Malthus

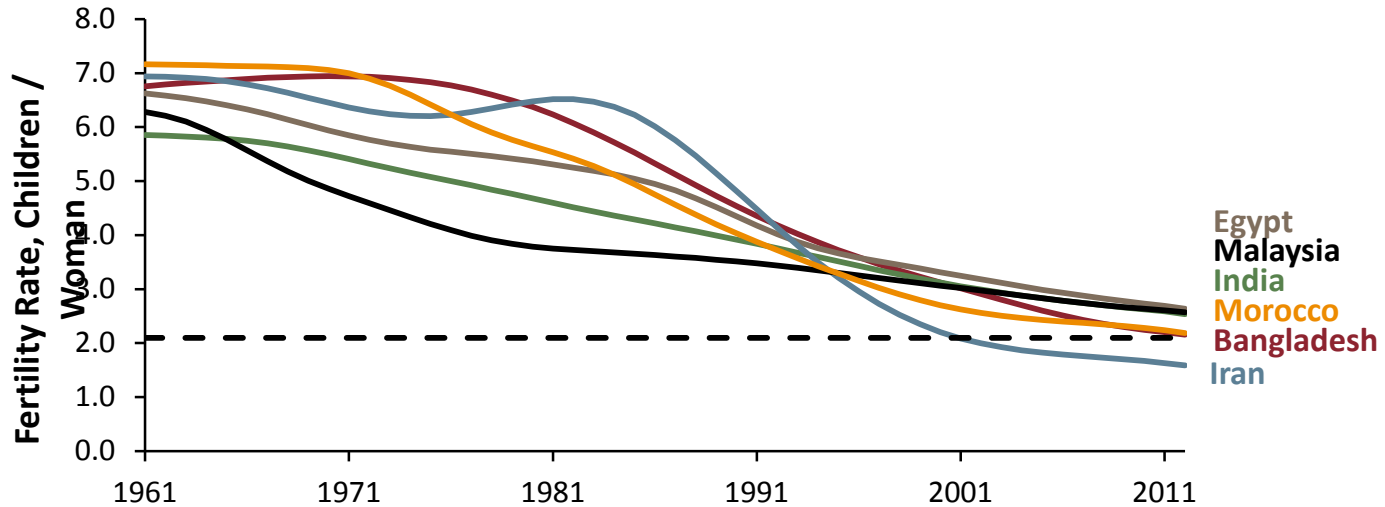


As of 12/31/12

Source: World Bank, Centers for Disease Control and Prevention

Fertility Rates Also Drop for Many Poorer Countries

Declines in Emerging Countries



As of 12/31/12

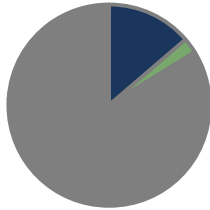
Source: World Bank

African Population: The Real Population Problem

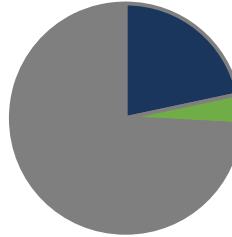
(in the higher UN estimate for 2100)

World Population

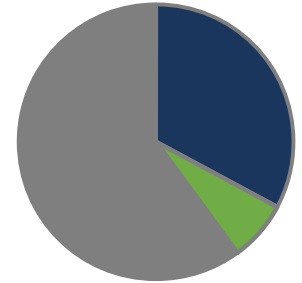
2015 Population: **7.4 Billion**



2050 Population: **9.8 Billion**



2100 Population: **11.2 Billion**



Total increase in population: 3.8 Bn

Of which:

■ **The Rest of the World**

↓
0.5 Bn

■ **Nigeria**

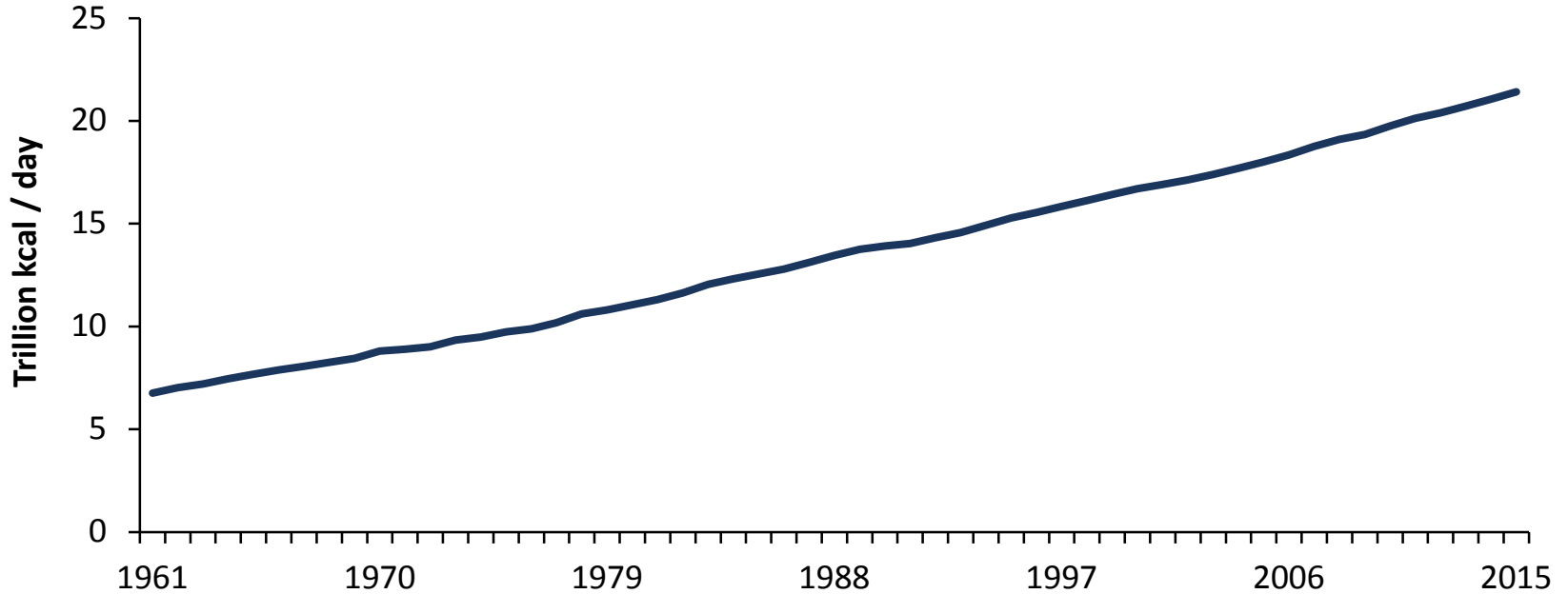
↓
0.6 Bn

■ **Africa**

↓
3.3 Bn

Total World Food Demand

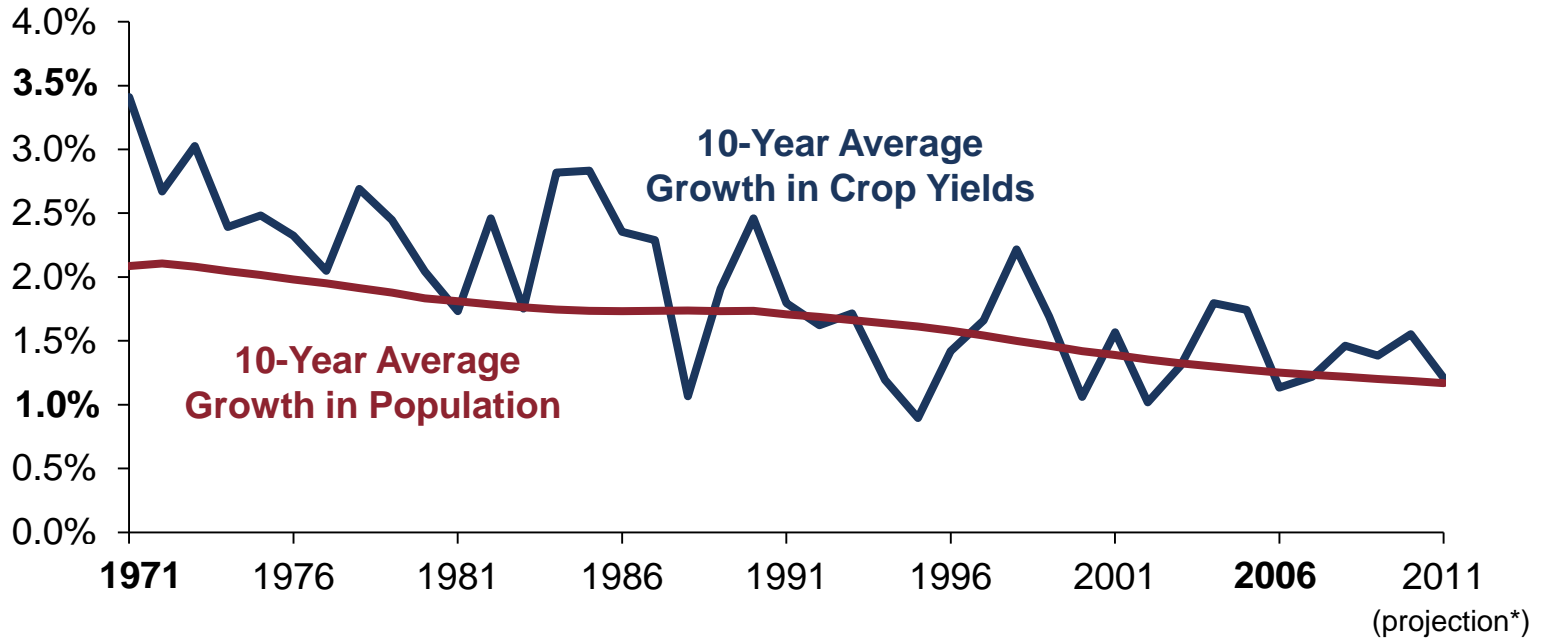
Trillions of kilocalories daily



As of Dec 2016

Source: FAOSTAT

10-Year Average Annual Growth In Crop Yields



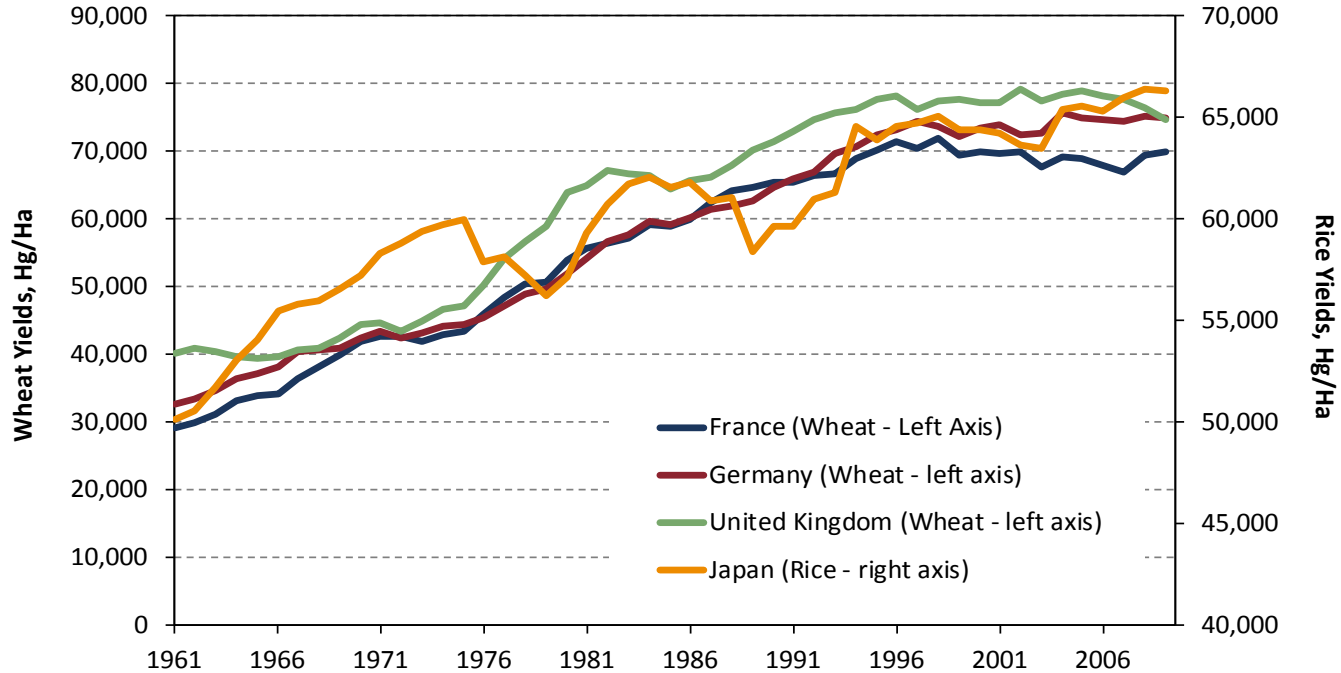
As of 9/17/12

Source: Food and Agriculture Organization of the United Nations, GMO

* 2011 crop yields is a projection; population data is actual.

Growth in Very Best Yielding Crops Slow Towards Zero

Crop Yields (5-Year Moving Average)

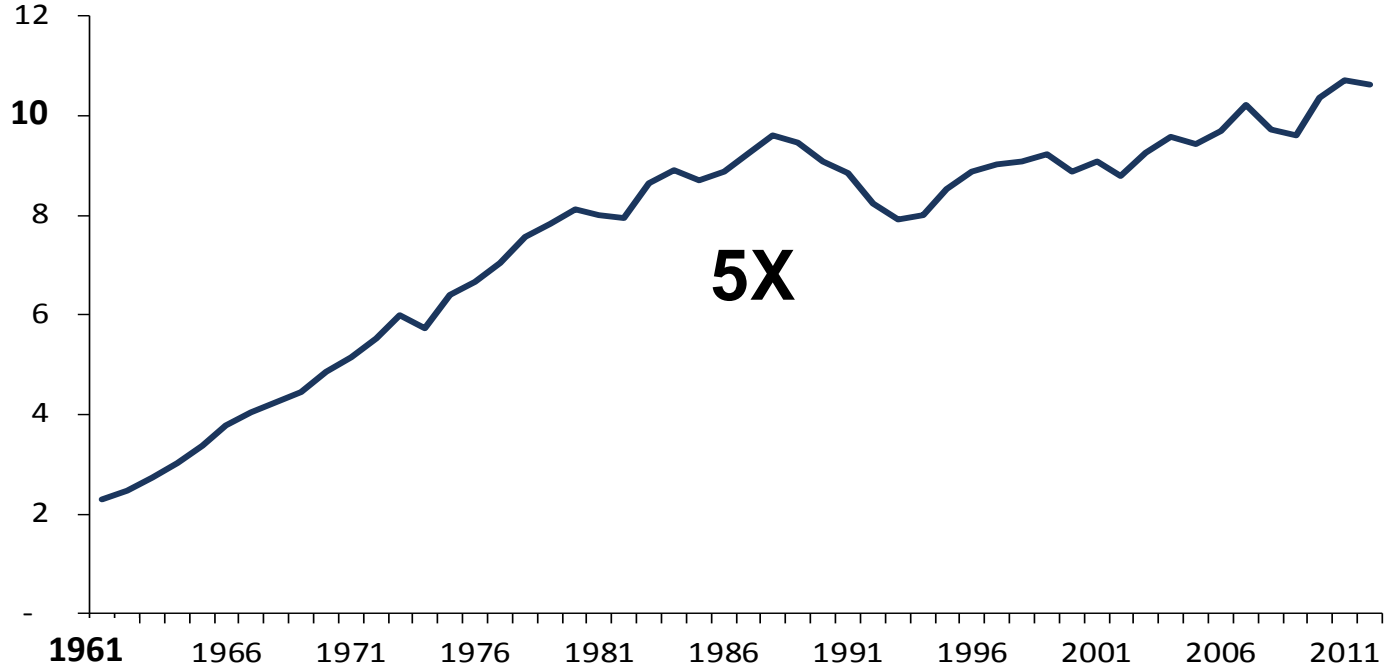


As of 12/31/13

Source: UN Food and Agriculture Organization

Fertilizer Use Starts to Max Out

Tons of fertilizer used annually

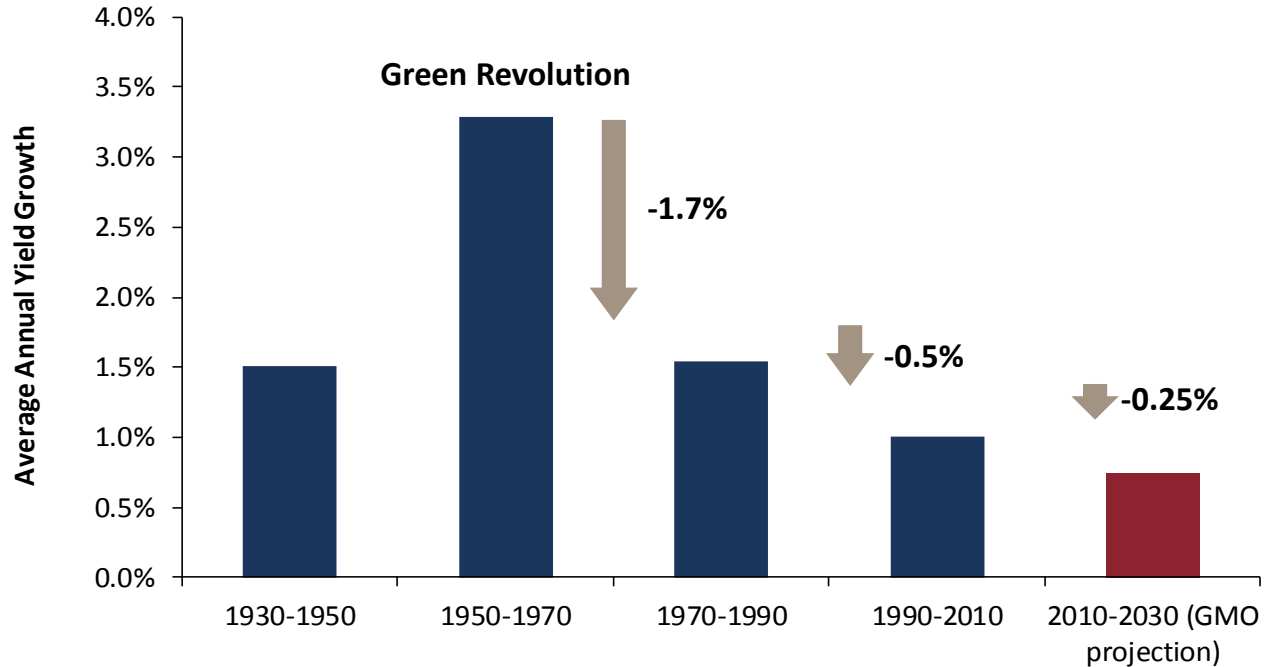


As of 12/31/12

Source: Food and Agriculture Organization of the United Nations

Grain Productivity Shows Diminishing Returns

Average Annual Agricultural Productivity Growth in the United States, by 20-year block
 Average of yield growth for corn, wheat and rice

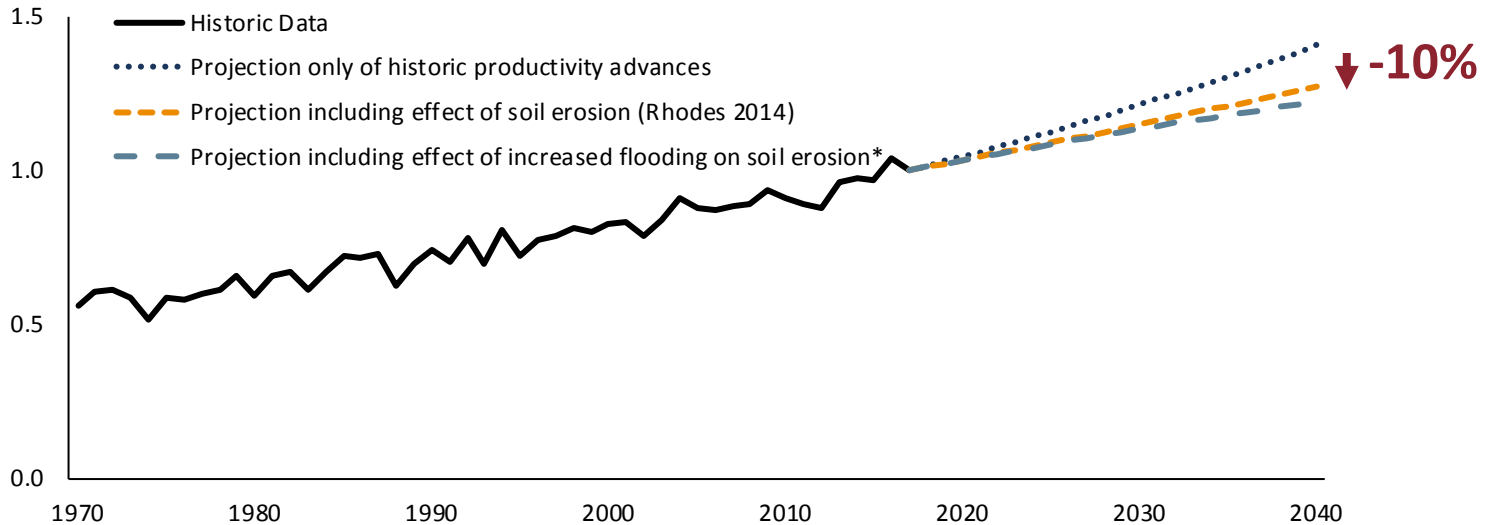


As of Jan 2018
 Source: USDA NASS

Effect of Erosion on Grain Production

U.S. Grain Yields, Historical and Projected

Index averaging corn, wheat, soy and rice yields, 2017 = 1



As of Jan 2018

Source: USDA NASS; "Soil Erosion, Climate Change and Global Food Security: Challenges and Strategies", Rhodes, *Science Progress*, 2014; GMO

Soil Depth in Iowa Has Halved Since Intensive Cultivation Began in 1850

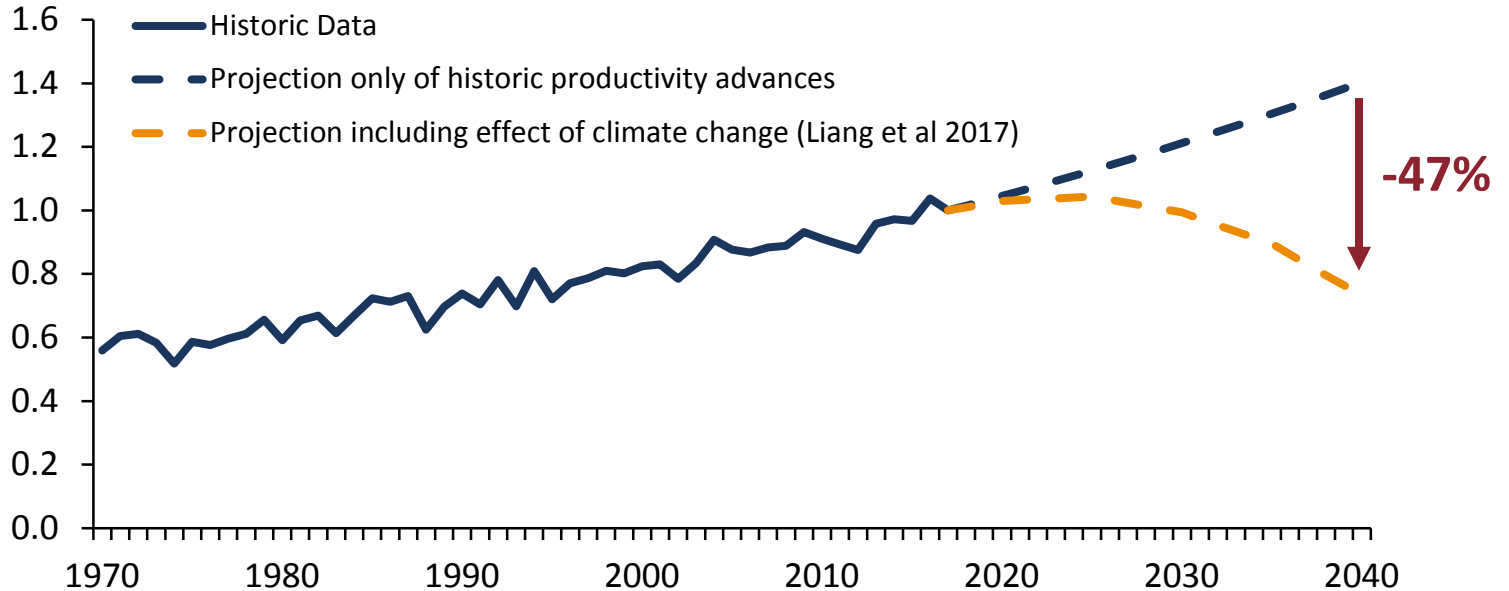


Image Source: Iowa Public Radio
“The Greatest Story Never Told”, installation in Adair County, Iowa, by David B. Dahlquist and RDG Planning & Design.

Effect of Climate Change on Grain Production

U.S. Grain Yields, Historical and Projected

Index averaging corn, wheat, soy and rice yields, 2017 = 1



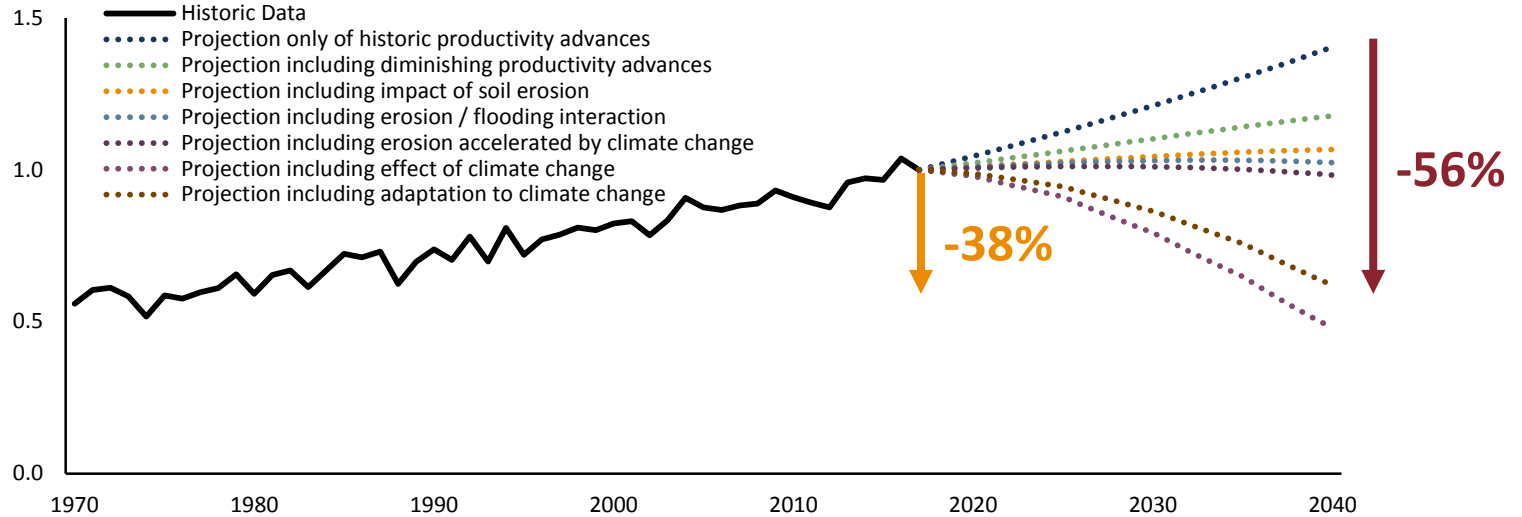
As of Jan 2018

Source: USDA NASS; "Determining Climate Effects on US Total Agricultural Productivity", Liang et al, *Proceedings of the National Academy of Sciences*; GMO

Combined Effect Climate Change & Soil Erosion

U.S. Grain Yields, Historical and Projected

Index averaging corn, wheat, soy and rice yields, 2017 = 1



As of Jan 2018

Source: USDA NASS, Rhodes 2014, Liang et al 2017, GMO

Other Problems Facing “Big Ag”

- Water availability
- Urban expansion
- Bug and pathogen immunity
- Toxic environment
 - 75% loss of flying insects
- Global distribution of phosphate reserves

Phosphate Distribution: A Nearly Certain Crisis

There are no substitutes for phosphorous in agriculture

Annual Production and Reserves (millions of metric tons)		
	Production (2010)	Reserves
Morocco and Western Sahara	26.0	50,000
World	176.0	65,000

As of 12/31/10

Source: USGS

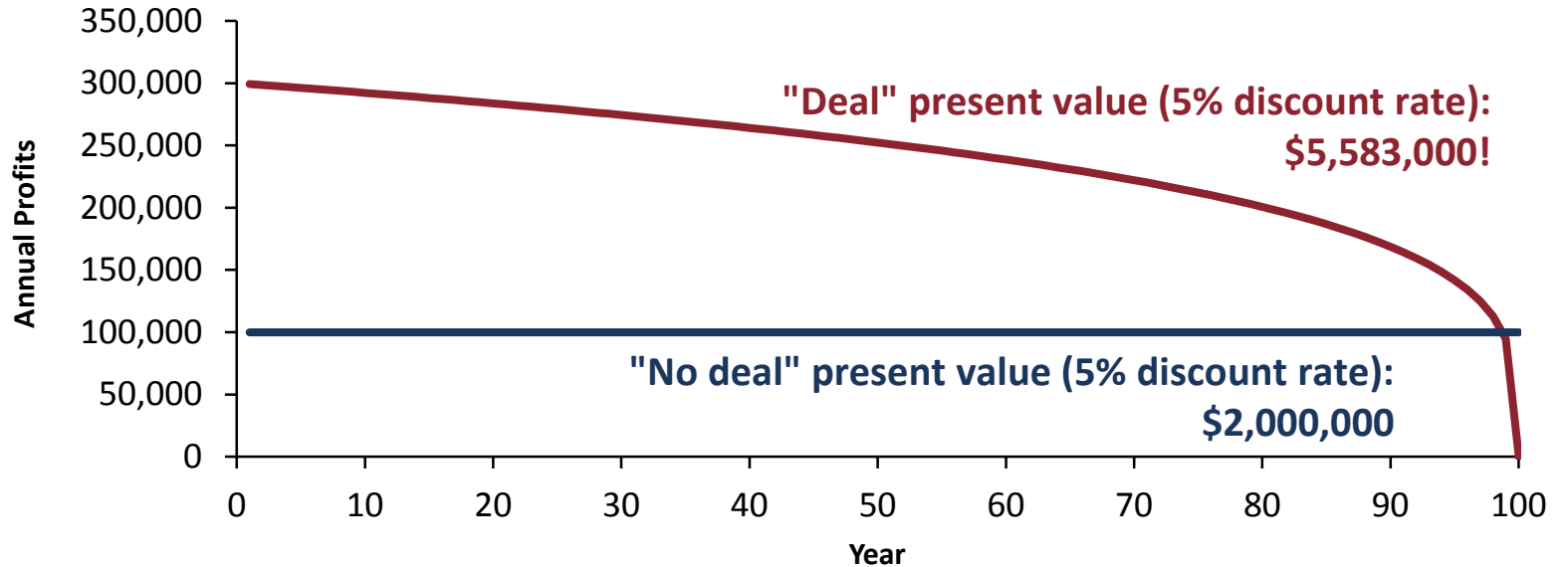
Climate Change: Problems with Capitalism

- The Sixth Great Extinction
- Toxicity affecting humans also: over 50% loss of sperm count in developed world
- Complete inability of capitalism to deal with externalities, tragedies of the commons, and the very long-term
- The Devil and the Farmer

The Devil's Deal: Your Soil & Your Soul!

Three times more profit now in exchange for 1% per year soil erosion over 100 years (i.e. complete)

Profits per year under deal and no deal



As of Jan 2018
Source: GMO

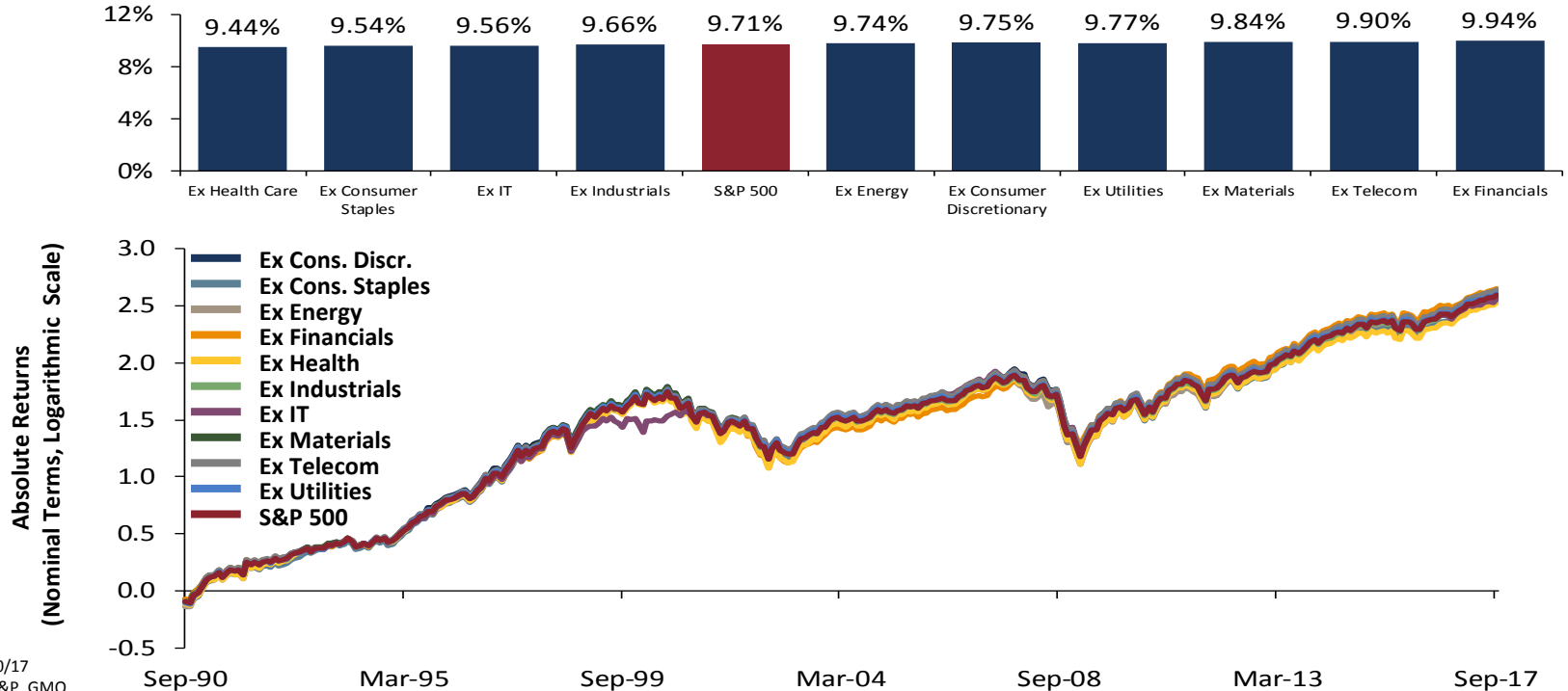
Illustrative Climate Change Portfolio (Global Equities)

Segment	Exposure
Clean Energy	34.58%
Solar	9.92%
Wind	5.61%
Other Clean Energy	0.95%
Clean Power Generation	10.45%
Batteries & Storage	7.66%
Smart Grid	5.44%
Copper	9.30%
Energy Efficiency	20.31%
Transportation	6.25%
Buildings	0.32%
Diversified Efficiency	7.81%
Technology	2.88%
Lighting	1.68%
Recycling	1.36%
Agriculture	23.18%
Farming	5.33%
Farm Machinery	2.51%
Timber	1.20%
Eco-Chemicals/Seeds	2.42%
Fertilizer	8.34%
Fish Farming	3.38%
Water	4.93%
Cash	2.25%

And Finally the Peril of Divestment!

Yes, You Can Divest From Oil – or Anything Else – Without Much Consequence

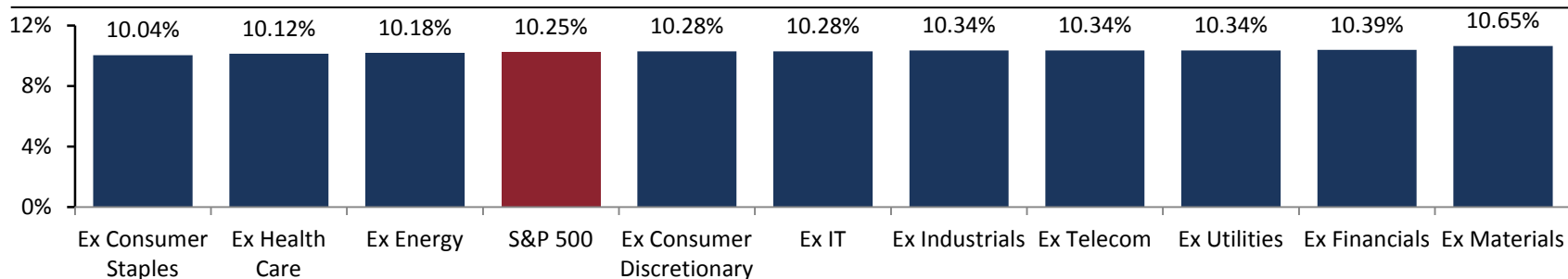
Annualized Absolute Returns (Nominal Terms): 1989-2017 – Range: 50 bps



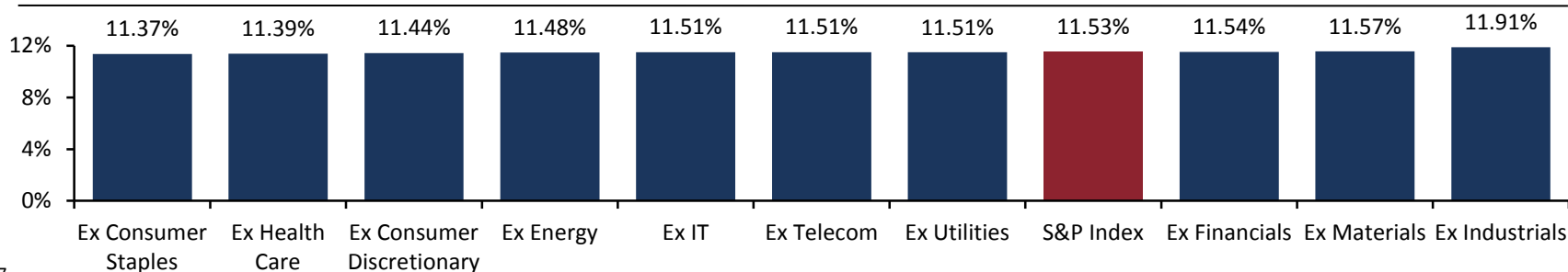
As of 9/30/17
Source: S&P, GMO

Yes, You Can Divest From Oil – or Anything Else – Without Much Consequence

1957-2017 Range: 61bps



1925-2017 Range: 54bps



As of 9/30/17

Source: S&P, GMO

Note: Prior to March 1957 the S&P 500 is represented by the S&P 90 Index