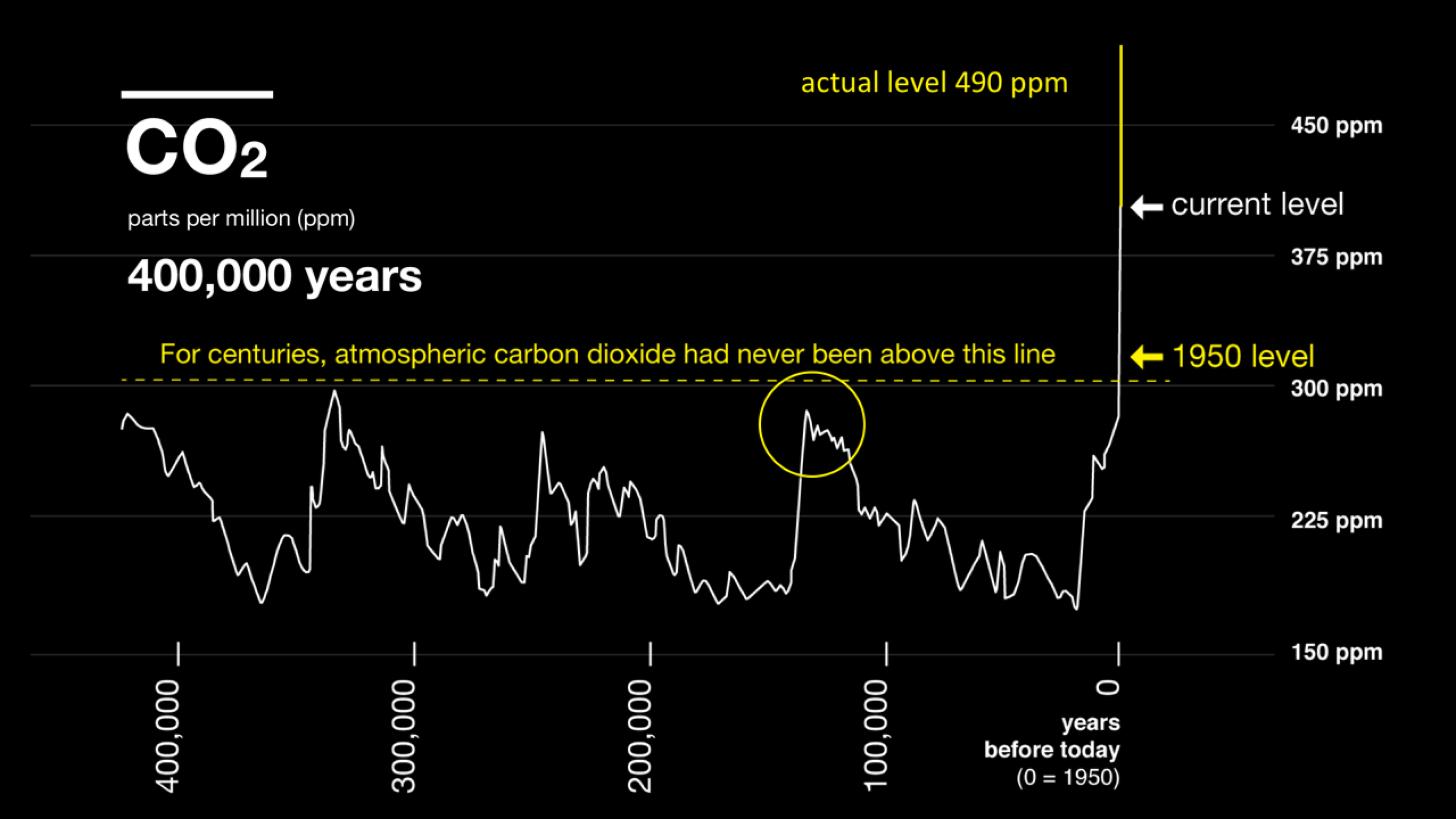
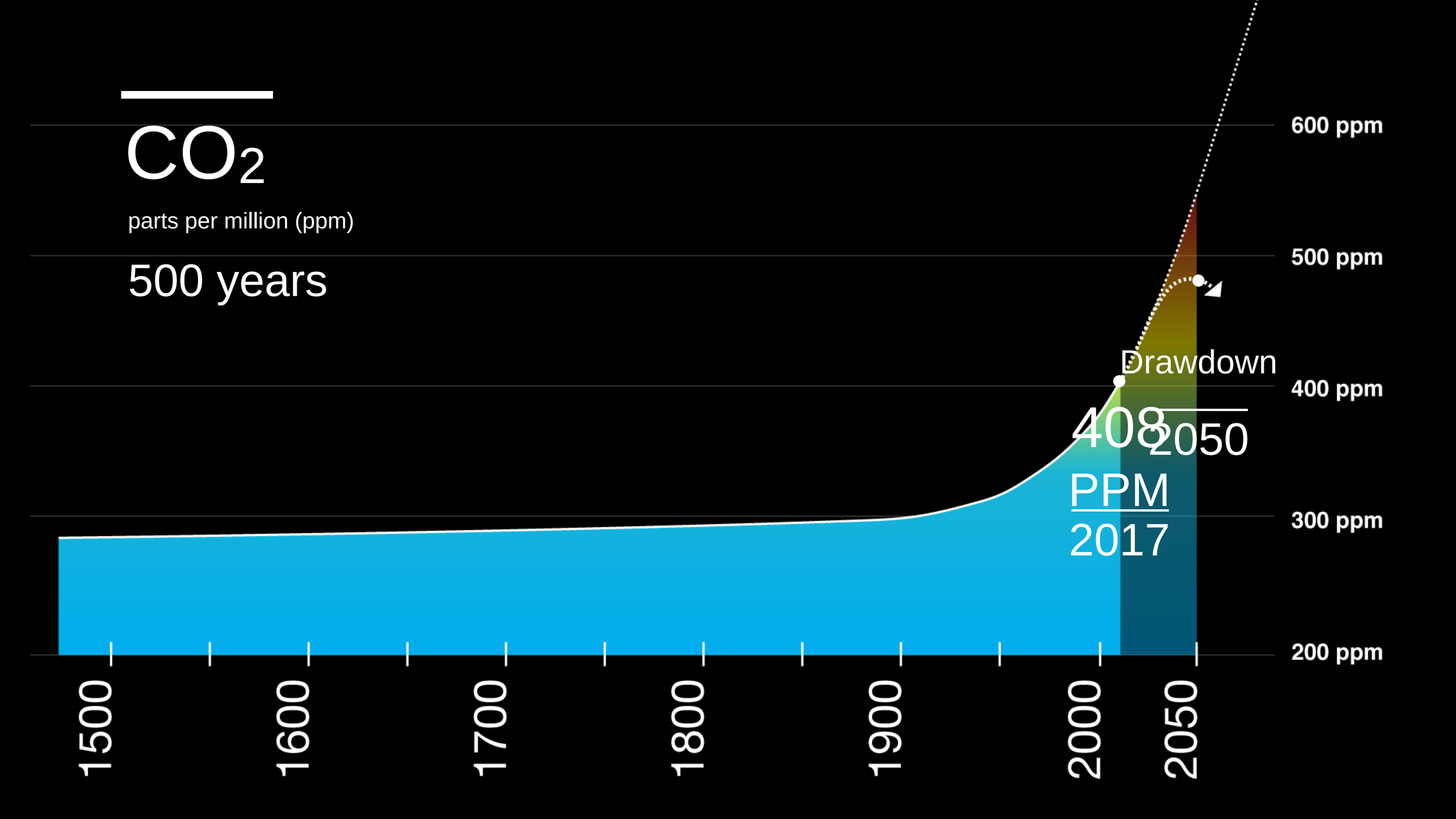
Sustainability Speaker Series 2018

Sunnyvale


DRAWDOWN


$\overline{CO_2}$
parts per million (ppm)
400,000 years
actual level 490 ppm
450 ppm
current level
375 ppm
For centuries, atmospheric carbon dioxide had never been above this line
1950 level
300 ppm
225 ppm
150 ppm
400,000
300,000
200,000
100,000
0
years
before today
(0 = 1950)


$\overline{CO_2}$
parts per million (ppm)
500 years
600 ppm
500 ppm
400 ppm
300 ppm
200 ppm
Drawdown
408 ppm
2017
2050
1500
1600
1700
1800
1900
2000
2050

How do we get the news about global warming?

Global warming could wipe out millions in world's major cities with catastrophic 'THREE METRE sea level rise'

18:44, 18 MAY 2016 | **UPDATED** 19:22, 18 MAY 2016 | **BY** JESSICA HAWORTH , STEPHEN BEECH

London, New York and Hong Kong are among the cities which could be underwater if global warming continues

★ Recommended In UK News

DANGEROUS DOGS
Blyth dog attack: 'Hero' schoolgirl saves seven-year-old from being mauled to death by crazed Staffie

INQUESTS
Wife 'smashed husband's head with frog ornament and kept him mummified in layers of sheeting for 18 years'

INCREDIBLE ESCAPES
Dashcam captures shocking moment huge bridge collapses and falls 60ft next to busy motorway

ISIS
ISIS murder 25 'spies' by tying them together and

THE DAILY CALLER NEWS FOUNDATION

Noah's ark during a rain and lightning storm. (Credit: Amanda Carden/Shutterstock)

'Potential Apocalypse': NYT Warns Of Global Warming Floods Of Biblical Proportions

MICHAEL BASTASCH

7:08 PM 05/20/2017

The New York Times has taken warnings about global warming to a whole new level, publishing a three-part series suggesting a "potential apocalypse" from melting ice sheets if humans keep pumping carbon dioxide into the atmosphere.

"If that ice sheet were to disintegrate, it could raise the level of the sea by more than 160 feet — a potential apocalypse, depending on exactly how fast it happened," NYT reporter Justin Gillis wrote of what some scientists predict could happen to Antarctica.


DRAWDOWN

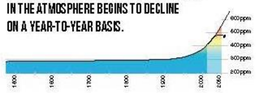
DRAWDOWN

100 SOLUTIONS TO REVERSE GLOBAL WARMING BY 2050

RANKED BY IMPACT

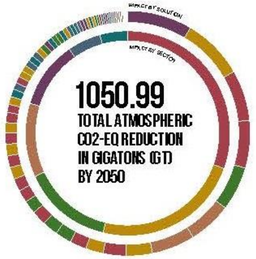
drawdown.org

DRAWDOWN IS THAT POINT IN TIME WHEN THE CONCENTRATION OF GREENHOUSE GASES IN THE ATMOSPHERE BEGINS TO DECLINE ON A YEAR-TO-YEAR BASIS.



Project Drawdown is the most comprehensive plan ever proposed to reverse global warming. Our organization did not make or devise the plan—we found the plan because it already exists. We gathered a qualified and diverse group of researchers from around the world to identify, research, and model the 100 most substantive, existing solutions to address climate change. What was uncovered is a path forward that can roll back global warming within thirty years. It shows that humanity has the means at hand. Our work is to accelerate the knowledge and growth of what is possible. We chose the name Drawdown because if we do not name the goal, we are unlikely to achieve it.

EACH SOLUTION REDUCES GREENHOUSE GASES BY AVOIDING EMISSIONS AND/OR BY SEQUESTERING CARBON DIOXIDE ALREADY IN THE ATMOSPHERE.



Afforestation—creating forests where there were none before—creates a carbon sink, drawing in and holding on to carbon and distributing it into the soil.

18.06 GT REDUCED CO2 #15

The airline industry produces at minimum 2.5 percent of emissions, and it is growing. Fuel efficiency measures are on the rise to reduce that impact.

5.05 GT REDUCED CO2 #43

Cement, a vital material for infrastructure, generates 5 to 6 percent of annual emissions. The key strategy to reduce them is to change its composition.

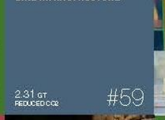
6.69 GT REDUCED CO2 #36

The artificial leaf is technology inspired by photosynthesis. It combines solar energy, water, and carbon dioxide, to feed bacteria that synthesize energy-dense fuel.

Autonomous vehicles are on the rise. They have the potential to shrink the auto fleet and accelerate ridesharing and the adoption of electric vehicles.

Bamboo rapidly sequesters carbon in biomass and soil and can thrive on degraded lands. It has more than 1,000 uses, from buildings to food to paper.

7.22 GT REDUCED CO2 #35



2.31 GT REDUCED CO2 #59

Food
BIOCHAR

Biochar results from slowly baking biomass in the absence of oxygen. Retaining most of the feedstock's carbon, biochar can be buried for sequestration, while enriching soil.

0.81 GT REDUCED CO2 #72

Materials
BIOPLASTIC

Ninety percent of plastics could be derived from plants instead of fossil fuels. Bio-plastics can be biodegradable and often have lower emissions.

4.30 GT REDUCED CO2 #47

Buildings and Cities
BUILDING AUTOMATION

Building automation systems serve as the "brain" of large commercial buildings. Controlling temperature, lighting, and more, they can improve energy efficiency and occupants' comfort.

4.62 GT REDUCED CO2 #45

Coming Attractions
BUILDING WITH WOOD

High-performance wood materials are transforming construction. They can reduce emissions by (1) sequestering and storing carbon and (2) avoiding emissions of cement and steel.

Transport
CARS

Hybrid cars pair an electric motor and battery with an internal combustion engine. The combination makes them more efficient, improving fuel economy and lowering emissions.

4.00 GT REDUCED CO2 #49

Food
CLEAN COOKSTOVES

Traditional cooking practices produce toxic smoke and 2 to 5 percent of annual greenhouse gas emissions. Clean cookstoves reduce emissions and protect human health.

15.81 GT REDUCED CO2 #21

Land Use
COASTAL WETLAND

The world's salt marshes, mangroves, and sea grasses provide vital habitat, flood protection, and water filtration, and sequester huge amounts of carbon in plants and soil.

3.19 GT REDUCED CO2 #52

Energy
COGENERATION

Power plants produce large amounts of waste heat. Cogeneration systems capture that thermal energy and put it to work—for district heating or additional electricity.

3.97 GT REDUCED CO2 #50

Food
COMPOSTING

From backyard bins to industrial-scale operations, composting food waste converts organic material into stable soil carbon and valuable fertilizer, averting methane emissions.

2.28 GT REDUCED CO2 #60

Energy
CONCENTRATED SOLAR

Concentrated solar power uses solar radiation as its primary fuel. Arrays of mirrors concentrate incoming rays to heat a fluid, produce steam, and turn turbines.

10.90 GT REDUCED CO2 #25

Food
CONSERVATION AGRICULTURE

Conservation agriculture avoids tilling and employs cover crops and crop rotation. By protecting the soil, it makes land more resilient and sequesters carbon.

17.35 GT REDUCED CO2 #16

Coming Attractions
DIRECT AIR CAPTURE

Direct Air Capture systems are a nascent sequestration technology. Functioning like a chemical sieve and sponge, they capture carbon dioxide from air and release it in purified form.

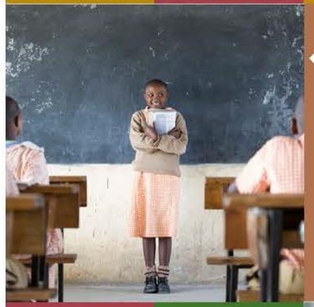
Coming Attractions
A COW WALKS ONTO A BEACH

Asparagopsis taxiformis, a species of seaweed, shows promise for reducing methane emissions from livestock—currently 4 to 5 percent of annual greenhouse gas emissions.

Buildings and Cities
DISTRICT HEATING

With district systems, a central plant channels hot and/or cool water via a network of pipes to many buildings—heating and cooling them more efficiently.

9.38 GT REDUCED CO2 #27



Women and Girls
EDUCATING GIRLS

Education lays a foundation for vibrant lives for girls and women, their families, and their communities. It also avoids emissions by curbing population growth.

59.60 GT REDUCED CO2 #6

Transport
ELECTRIC BIKES

Electric bikes get a boost from a small battery-powered motor. They are the most environmentally sound means of motorized transport in the world today.

0.96 GT REDUCED CO2 #69

Transport
ELECTRIC VEHICLES

Electric vehicles are the cars of the future. If powered by solar energy, their carbon dioxide emissions drop by 95 percent compared to gasoline-powered vehicles.

10.80 GT REDUCED CO2 #26

Energy
ENERGY STORAGE (DISTRIBUTED)

Standalone batteries and electric vehicles make it possible to store energy at home or work. They ensure supply even when variable renewables are not producing.

AN ENABLING TECHNOLOGY. COST AND SAVINGS ARE EMBEDDED IN RENEWABLE ENERGY

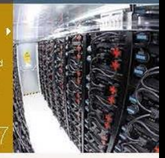
#77

Energy
ENERGY STORAGE (UTILITIES)

Energy storage—daily, multiday, and longer-term or seasonal—is vital to reduce emissions from polluting "peaker" plants and accommodate the shift to variable renewables.

AN ENABLING TECHNOLOGY. COST AND SAVINGS ARE EMBEDDED IN RENEWABLE ENERGY

#77



Coming Attractions
ENHANCED WEATHERING OF MINERALS

Natural weathering of silicate rock sequesters carbon dioxide. Enhanced weathering aims to hasten that process by milling rock powder and applying it to landscapes.

Women and Girls
FAMILY PLANNING

Securing women's right to voluntary, high-quality family planning dramatically improves the health and well-being of women and their children. It also avoids emissions.

59.60 GT REDUCED CO2 #7

Food
FARMLAND IRRIGATION

Pumping and distributing water requires large quantities of energy. Drip and sprinkler irrigation, among other practices and technologies, make water use more precise and efficient.

1.33 GT REDUCED CO2 #67

Food
FARMLAND RESTORATION

The world's abandoned farmland is an opportunity for drawdown. Restoring it sequesters carbon and can improve food security, farmers' livelihoods, and ecosystem health.

14.08 GT REDUCED CO2 #23

Land Use
FOREST PROTECTION

With mature canopy trees and complex understories, primary forests contain 300 billion tons of carbon and are the greatest reservoirs of biodiversity on the planet.

6.20 GT REDUCED CO2 #38

Energy
GEOTHERMAL

Geothermal power—literally "earth heat"—taps into underground reservoirs of steam, hot water, which can be piped to the surface to drive turbines that produce electricity.

16.60 GT REDUCED CO2 #18

Buildings and Cities
GREEN ROOFS

Green roofs use soil and vegetation as living insulation. Cool roofs reflect solar energy. Both reduce building energy use for heating and/or cooling.

0.77 GT REDUCED CO2 #73

Energy
GRID FLEXIBILITY

For electricity supply to become predominantly or entirely renewable, the grid needs to become more flexible and adaptable than it is today.

AN ENABLING TECHNOLOGY. COST AND SAVINGS ARE EMBEDDED IN RENEWABLE ENERGY

#77

Buildings and Cities
HEAT PUMPS

Heat pumps transfers heat from a cold space to a hot one. Highly efficient, they can dramatically lower building energy use for heating and cooling.

5.20 GT REDUCED CO2 #42

Transport
HIGH-SPEED RAIL

High-speed rail is the fastest way to travel distances between 100 to 700 miles. Compared to driving or flying, it reduces emissions up to 90 percent.

1.52 GT REDUCED CO2 #66

Materials
HOUSEHOLD RECYCLING

Household recycling can reduce emissions because producing new products from recovered materials often saves energy. It also reduces resource extraction and creates jobs.

2.77 GT REDUCED CO2 #55

Coming Attractions
HYDROGEN-BORON FUSION

Tri Alpha Energy has achieved one-half of the nuclear fusion equation. It could herald clean, safe, affordable energy to take the world beyond fossil fuels.

Coming Attractions
HYPERLOOP

The promise of Hyperloop is speed. The virtue is moving people and cargo with 90 to 95 percent less energy than planes, trains, or cars.

Food
IMPROVED RICE CULTIVATION

Flooded rice paddies produce large quantities of methane—10 percent of agricultural emissions. Techniques exist to reduce methane, while improving production and sequestering carbon.

11.34 GT REDUCED CO2 #24

Energy
IN-STREAM HYDRO

Placed within a free-flowing river or stream, in-stream turbines capture water's energy without a dam. In remote communities, they can replace expensive, dirty diesel generators.

4.00 GT REDUCED CO2 #48

Land Use
INDIGENOUS PEOPLES' LAND MANAGEMENT

Growing the acreage under secure indigenous land tenure can increase above- and belowground carbon stocks and reduce greenhouse gas emissions from deforestation.

6.19 GT REDUCED CO2 #39

Coming Attractions
INDUSTRIAL HEMP

Hemp is a global warming solution primarily because of what it can replace: cotton. Cotton has high chemical use and depends on fossil fuel inputs.

Materials
INDUSTRIAL RECYCLING

Industrial recycling reduces emissions when new products are made from recovered materials, rather than virgin resources. It can also address the challenge of resource scarcity.

2.77 GT REDUCED CO2 #56

Buildings and Cities
INSULATION

Insulation is one of the most cost-effective ways to make buildings more energy efficient—both in new construction and through retrofitting older buildings.

8.27 GT REDUCED CO2 #31

Coming Attractions
INTENSIVE SILVOPASTURE

Intensive silvopasture intercrops a leguminous woody shrub with grasses and trees. Through rapid rotational grazing, livestock yields increase alongside carbon sequestration in soil.

Buildings and Cities
LANDFILL METHANE

Landfills are a top source of methane emissions. Instead, landfill methane can be captured, preventing emissions, and used as a fairly clean energy source.

2.50 GT REDUCED CO2 #58

Buildings and Cities
LED LIGHTING (COMMERCIAL)

Lighting accounts for 15 percent of global electricity use. LEDs (light emitting diodes) require less energy and create less waste heat than other bulbs.

5.04 GT REDUCED CO2 #44

Buildings and Cities
LED LIGHTING (HOUSEHOLD)

By transferring most of their energy use into creating light—rather than heat, like older technologies—LEDs reduce electricity consumption and air-conditioning loads.

7.61 GT REDUCED CO2 #33

Coming Attractions
LIVING BUILDINGS

The Living Building Challenge holistically defines how buildings can benefit both people and planet. One key criteria: Living buildings produce more energy than they use.

Food
MANAGED GRAZING

Managed grazing imitates the activity of migratory herds to improve soil health, carbon sequestration, water retention, and forage productivity.

16.34 GT REDUCED CO2 #19

Coming Attractions
MARINE PERMACULTURE

Marine permaculture utilizes floating, latticed structures designed to grow rich kelp forests and foster marine life. It could sequester billions of tons of carbon dioxide.

Transport
MASS TRANSIT

Riding a streetcar, bus, or subway—rather than driving a car or hailing a cab—exerts greenhouse gases, release traffic congestion, and reduces air pollution.

6.57 GT REDUCED CO2 #37

Energy
METHANE DIGESTERS (LARGE)

Industrial-scale anaerobic digesters control decomposition of organic waste, and thus its methane emissions. They also produce Biogas, an energy source, and digestate, a nutrient-rich fertilizer.

8.40 GT REDUCED CO2 #30

Energy
METHANE DIGESTERS (SMALL)

At backyard- and farm yard-scale, anaerobic digesters are used to manage organic waste. They control methane emissions, while producing biogas (an energy source) and digestate (nutrient-rich fertilizer).

1.90 GT REDUCED CO2 #64

Energy
MICRO WIND

With capacity of 100 kilowatts or less, micro wind turbines are often used to pump water, charge batteries, and provide electrification in rural locations.

0.20 GT REDUCED CO2 #76

Coming Attractions
MICROBIAL FARMING

Microbes have the potential to dramatically reduce the need for synthetic fertilizers, pesticides, and herbicides, while improving crop yields and plant health.

Energy
MICROGRIDS

A microgrid is a localized grouping of distributed energy sources, like solar and wind, together with energy storage or backup generation and load management tools.

AN ENABLING TECHNOLOGY. COST AND SAVINGS ARE EMBEDDED IN RENEWABLE ENERGY

#78

Food
MULTISTRATA AGROFORESTRY

Multistrata agroforestry blends taller trees and one or more layers of crops. It achieves high rates of carbon sequestration, similar to forests, while producing food.

9.26 GT REDUCED CO2 #28

Buildings and Cities
NET ZERO BUILDINGS

A net zero building is one that has zero net energy consumption, producing as much energy, through onsite renewables, as it uses in a year.

COST AND SAVINGS MODELED IN RENEWABLE ENERGY AND OTHER TECHNOLOGIES

#79

Energy
NUCLEAR

Nuclear power is complex, expensive, and risky, but it has the potential to avoid emissions from fossil fuel electricity. We consider it a "regrets solution."

16.09 GT REDUCED CO2 #20

Food
NUTRIENT MANAGEMENT

When overused, nitrogen fertilizers destroy soil organic matter, pollute waterways, and create nitrous oxide. They can be more efficiently managed to reduce these negative impacts.

1.81 GT REDUCED CO2 #65

Coming Attractions
OCEAN FARMING

Small-scale ocean farms have the potential to provide sustainable food and biofuel, while oysters filter nitrogen pollution and seaweed sequesters carbon dioxide.

The Coalition

Leo Burke
University of Notre Dame

Mary Evelyn Tucker, PhD
Yale

Andy Revkin
The New York Times

Molly Jahn, PhD
University of Wisconsin

Robyn McCord O’Brien
Author

Janine Benyus
Biomimicry Institute

Dan Weiden
Weiden + Kennedy

Mark Mykleby
U.S. Navy

Karen O’Brien, PhD
IPCC

Spencer Beebe
Ecotrust

Peggy Liu
JUCCCE

Michael Pollan
Author, Professor

David Addison
Virgin Earth Challenge

André Heinz
Heinz Foundation

Kerry Kennedy
Robert F Kennedy Center

James Boyle
Sustainable Roundtable

Cutler Cleveland, PhD
Boston University

Edward Davey
The Prince of Wales’ International Sustainability Unit

John Elkington
Volans Ventures

Maria Fujihara
Brazil Green Bldg Council

Dan Kammen, PhD
IPCC, UC Berkeley

Sir Jonathon Porritt
Forum for the Future

Tom Steyer
NextGen Climate

Jules Kortenhorst
Rocky Mountain Institute

Sarah Bergmann
Pollinator Pathways

Adam Chambers, PhD
USDA Natural Resources Conservation Service

Joylette Portlock, PhD
Communitopia

Michael Mann, PhD
Pennsylvania State University

Clayton Thomas-Muller
Idle no More

Mehjabeen Abidi-Habib, PhD
Government College University in Lahore

Bill McKibben
350.org

Chris Pyke, PhD
IPCC

Brendan Mackey, PhD
Griffith University, Australia

Project Drawdown maps and models solutions

The Models

- **Reduction and Replacement Solutions (RRS) Model** → energy and energy efficiency solutions.
- **Land Use Solutions (LAND) Model** → land-based solutions with biosequestration potential.
- **Food System** → integrated supply-side solutions based on country-scale consumption patterns.

Modeling Solutions

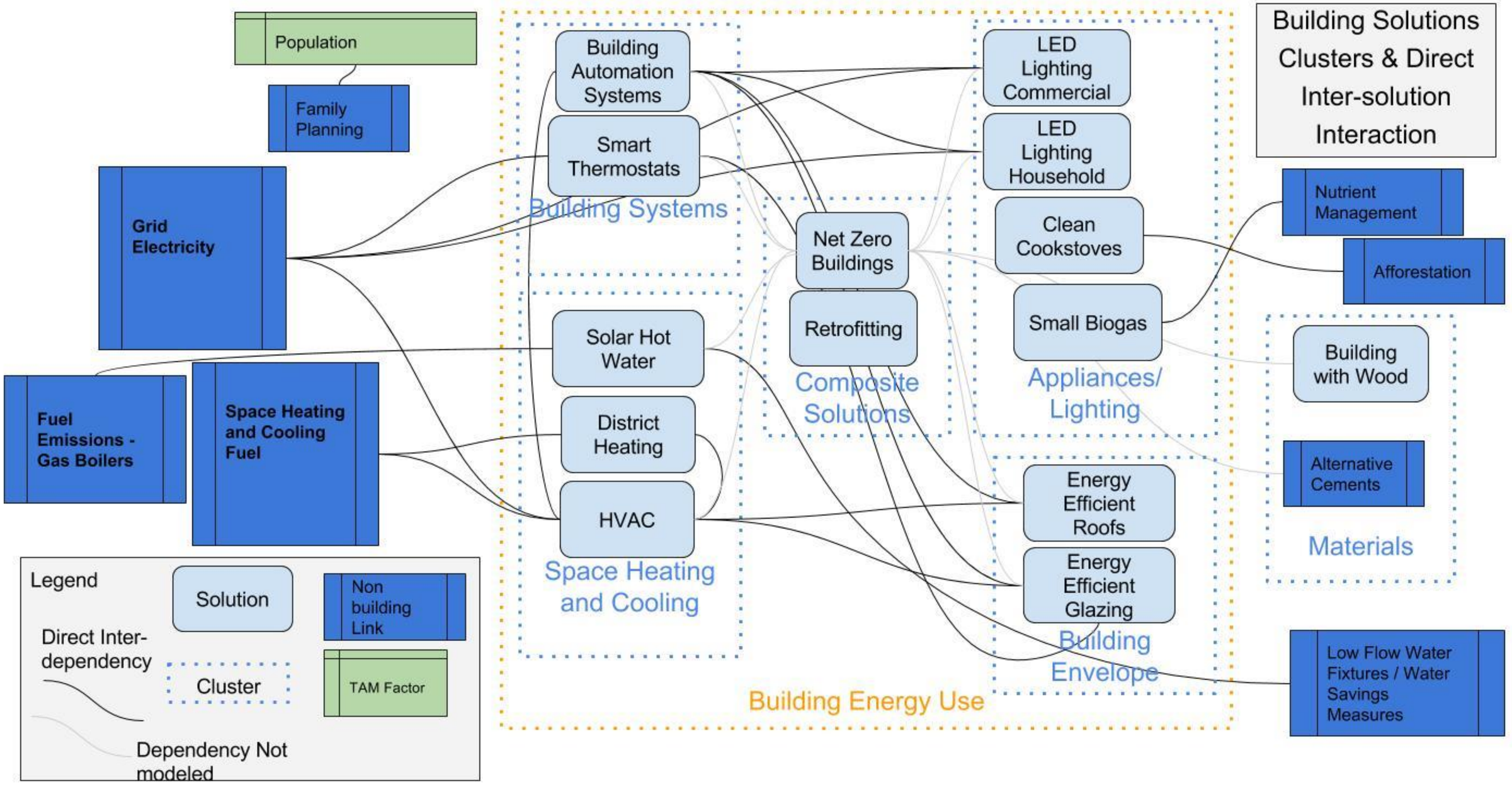
- We Compared a High Growth of Solution to Relatively Low Reference Adoption
- Each Solution was Compared to the Conventional High-Emitting Option
- Adoption Projections Are Used to Estimate Emissions and Financial Impact (first and operating cost differences)

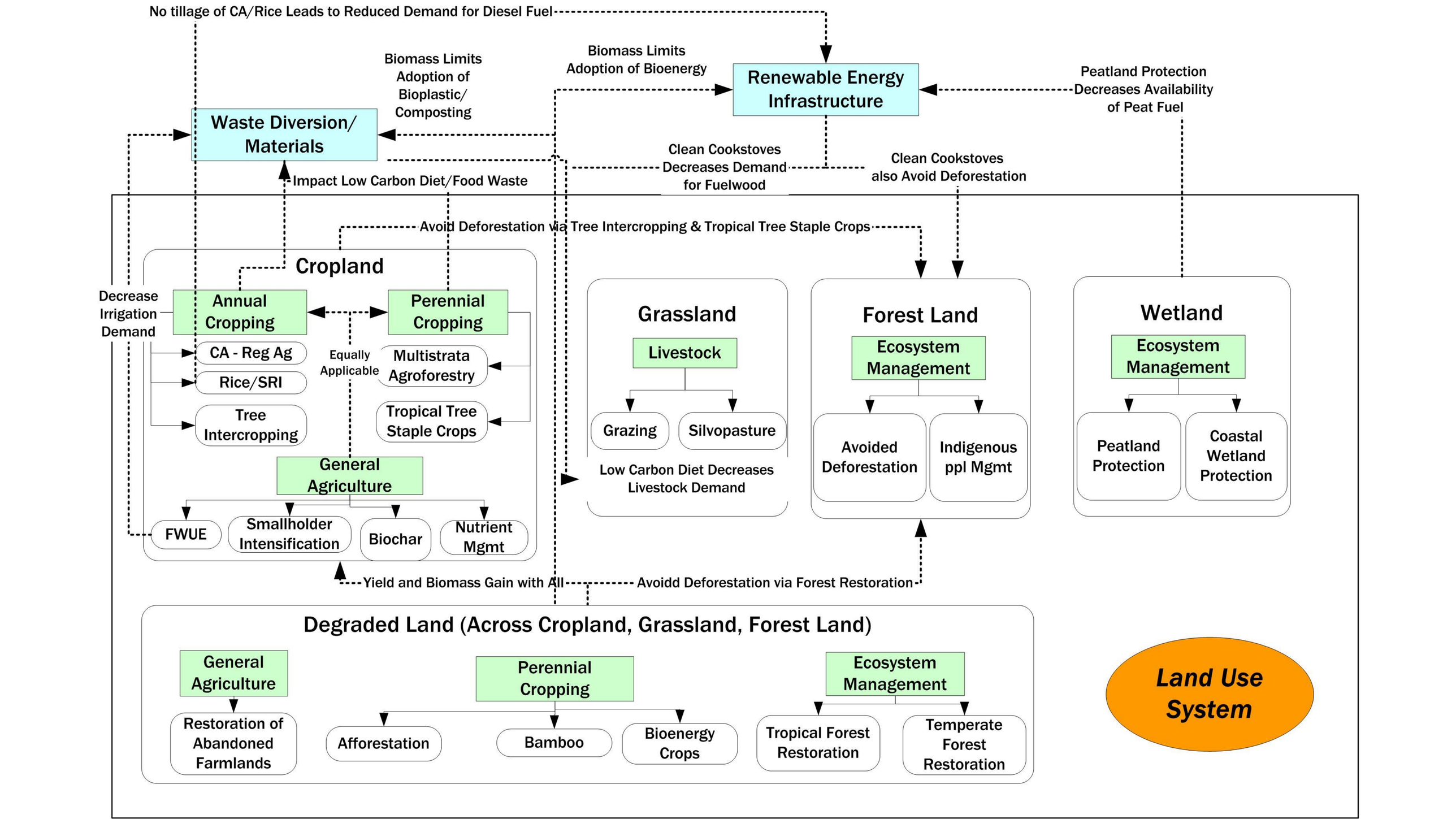
The Scenarios

High adoption scenarios assume a reasonably vigorous global adoption path.

Three scenarios were developed:

1. Plausible Scenario
2. Drawdown Scenario
3. Optimum Scenario


Building Solutions Clusters & Direct Inter-solution Interaction
Population
Family Planning
Grid Electricity
Fuel Emissions - Gas Boilers
Space Heating and Cooling Fuel
Building Automation Systems
Smart Thermostats
Building Systems
Solar Hot Water
District Heating
HVAC
Space Heating and Cooling
Net Zero Buildings
Retrofitting
Composite Solutions
LED Lighting Commercial
LED Lighting Household
Clean Cookstoves
Small Biogas
Appliances/ Lighting
Energy Efficient Roofs
Energy Efficient Glazing
Building Envelope
Nutrient Management
Afforestation
Building with Wood
Alternative Cements
Materials
Low Flow Water Fixtures / Water Savings Measures
Building Energy Use
Legend
Solution
Non building Link
Direct Inter-dependency
Cluster
TAM Factor
Dependency Not modeled


No tillage of CA/Rice Leads to Reduced Demand for Diesel Fuel
Biomass Limits Adoption of Bioplastic/ Composting
Biomass Limits Adoption of Bioenergy
Renewable Energy Infrastructure
Peatland Protection Decreases Availability of Peat Fuel
Waste Diversion/ Materials
Clean Cookstoves Decreases Demand for Fuelwood
Clean Cookstoves also Avoid Deforestation
Impact Low Carbon Diet/Food Waste
Avoid Deforestation via Tree Intercropping & Tropical Tree Staple Crops
Cropland
Decrease Irrigation Demand
Annual Cropping
Perennial Cropping
CA - Reg Ag
Rice/SRI
Tree Intercropping
Equally Applicable
Multistrata Agroforestry
Tropical Tree Staple Crops
General Agriculture
FWUE
Smallholder Intensification
Biochar
Nutrient Mgmt
Grassland
Livestock
Grazing
Silvopasture
Low Carbon Diet Decreases Livestock Demand
Forest Land
Ecosystem Management
Avoided Deforestation
Indigenous ppl Mgmt
Wetland
Ecosystem Management
Peatland Protection
Coastal Wetland Protection
Yield and Biomass Gain with All
Avoidd Deforestation via Forest Restoration
Degraded Land (Across Cropland, Grassland, Forest Land)
General Agriculture
Restoration of Abandoned Farmlands
Perennial Cropping
Afforestation
Bamboo
Bioenergy Crops
Ecosystem Management
Tropical Forest Restoration
Temperate Forest Restoration
Land Use System

Waste Solutions Clusters and Direct Inter-solution Interaction

Food Production:
Agro-forestry
Conservation Agriculture
Grazing & Pasture Management
Silvopasture
Sustainable Rice Production
Farm Water Use Efficiency
Tropical Staple Tree Crops

Population

Family Planning

Low Impact Diet

Bioplastics

Reduced Food Waste

Organic Fraction

Plastics

Total MSW (all Fractions)

Paper

Composting

Large Scale AD

Waste to Energy

CoGen/ CHP

Methane Landfill Capture

Commercial & Household Recycling

Recycled Paper

Waste Management

Nutrient Management (Bioseq)

Avoided Deforestation

Alternatives to Cement

Refrigerant Management

Solar Hot Water

Water Distribution Efficiency

Low Flow Water Fixtures / Water Savings Measures

Municipal Water

Micro Irrigation

Farm Water

Legend

Solution

Non waste Link

Direct Inter-dependency

Cluster

TAM Factor

The Results

NEW YORK TIMES BESTSELLER

DRAWDOWN

THE MOST COMPREHENSIVE PLAN EVER PROPOSED TO REVERSE GLOBAL WARMING

EDITED BY PAUL HAWKEN

ENERGY

ROOFTOP SOLAR

RANKING AND RESULTS BY 2050

#15

17.81 GIGATONS REDUCED CO_2	$1.07 TRILLION NET COST	$4.82 TRILLION LIFETIME SAVINGS

The year was 1884, when the first solar array appeared on a rooftop in New York City. Experimentalist Charles Fritts installed it after discovering that a thin layer of selenium on a metal plate could produce a current of electricity when exposed to light. How light could turn on lights, he and his solar-pioneering contemporaries did not know, for the mechanics were not understood until the early twentieth century when, among other breakthroughs, Albert Einstein published his revolutionary work on what are now called photons. Though the scientific establishment of Fritts' day believed power generation depended on heat, Fritts was convinced that "photoelectric" modules would wind up competing with coal-fired power plants. The first such plant had been brought online by Thomas Edison just two years earlier, also in New York City.

Today, solar is replacing electricity generated from coal as well as from natural gas. It is replacing kerosene lamps and diesel generators in places where people lack access to the power grid, true for more than a billion people around the world. While society grapples with electricity's pollution in some places and its absence in others, the mysterious waves and particles of the sun's light continuously strike the surface of the planet with an energy more than ten thousand times the world's total use. Small-scale photovoltaic systems, typically sited on rooftops, are playing a significant role in harnessing that light, the most abundant resource on earth. When photons strike the thin wafers of silicon crystal within a vacuum-sealed solar panel, they knock electrons loose and produce an electrical circuit. These subatomic particles are the only moving parts in a solar panel, which requires no fuel.

While solar photovoltaics (PV) provide less than 2 percent of the world's electricity at present, PV has seen exponential growth over the past decade. In 2015 distributed systems of less than 100 kilowatts accounted for roughly 30 percent of solar PV capacity installed worldwide. In Germany, one of the world's solar leaders, the majority of photovoltaic capacity is on rooftops, which don 1.5 million systems. In Bangladesh, population 157 million, more than 3.6 million home solar systems have been installed. Fully 16 percent of Australian homes have them. Transforming a square meter of rooftop into a miniature power station is proving irresistible.

An Uros mother and her two daughters live on one of the 42 floating islands made of totora reeds on Lake Titicaca. Their delight upon receiving their first solar panel is infectious. Installed at an elevation of 12,507 feet, the panel will replace kerosene and provide electricity to her family for the first time. As high tech as solar may be, it is a perfect cultural match: The Uru People know themselves as Lupihaques, Sons of the Sun.

Roof modules are spreading around the world because of their affordability. Solar PV has benefited from a virtuous cycle of falling costs, driven by incentives to accelerate its development and implementation, economies of scale in manufacturing, advances in panel technology, and innovative approaches for end-user financing—such as the third-party ownership arrangements that have helped mainstream solar in the United States. As demand has grown and production has risen to meet it, prices have dropped; as prices have dropped, demand has grown further. A PV manufacturing boom in China has helped unleash a torrent of inexpensive panels around the world. But hard costs are only one side of the expense equation. The soft costs of financing, acquisition, permitting, and installation can be half the cost of a rooftop system and have not seen the same dip as panels themselves. That is part of the reason rooftop solar is more expensive than its utility-scale kin. Nonetheless, small-scale PV already generates electricity more cheaply than it can be brought from the grid in some parts of the United States, in many small island states, and in countries including Australia, Denmark, Germany, Italy, and Spain.

The advantages of rooftop solar extend far beyond price. While the production of PV panels, like any manufacturing process, involves emissions, they generate electricity without emitting greenhouse gases or air pollution—with the infinite resource of sunlight as their sole input. When placed on a grid-connected roof, they produce energy at the site of consumption, avoiding the inevitable losses of grid transmission. They can help utilities meet broader demand by feeding unused electricity into the grid, especially in summer, when solar is humming and electricity needs run high. This "net metering" arrangement, selling excess electricity back to the grid, can make solar panels financially feasible for homeowners, offsetting the electricity they buy at night or when the sun is not shining.

Numerous studies show that the financial benefit of rooftop PV runs both ways. By having it as part of an energy-generation portfolio, utilities can avoid the capital costs of additional coal or gas plants, for which their customers would otherwise have to pay, and broader society is spared the environmental and public health impacts. Added PV supply at times of highest electricity demand can also curb the use of expensive and polluting peak generators. Some utilities reject this proposition and posit contradictory claims of rooftop PV being a "free rider," as they aim to block the rise of distributed solar and its impact on their revenue and profitability. Others accept its inevitability and are trying to shift their business models accordingly. For all involved, the need for a grid "commons" continues, so utilities, regulators, and stakeholders of all stripes are evolving approaches to cover that cost.

The first solar array installed by Charles Fritts in 1884 in New York City. Fritts built the first solar panels in 1881, reporting that the current was "continuous, constant and of considerable force not only by exposure to

Off the grid, rooftop panels can bring electricity to rural parts of low-income countries. Just as mobile phones leapfrogged installation of landlines and made communication more democratic, solar systems eliminate the need for large-scale, centralized power grids. High-income countries dominated investment in distributed solar until 2014, but now countries such as Chile, China, India, and South Africa have joined in. It means rooftop PV is accelerating access to affordable, clean electricity and thereby becoming a powerful tool for eliminating poverty. It is also creating jobs and energizing local economies. In Bangladesh alone, those 3.6 million home solar systems have generated 115,000 direct jobs and fifty thousand more downstream.

Since the late nineteenth century, human beings in many places have relied on centralized plants that burn fossil fuels and send electricity out to a system of cables, towers, and poles. As households adopt rooftop solar (increasingly accompanied and enabled by distributed energy storage), they transform generation and its ownership, shifting away from utility monopolies and making power production their own. As electric vehicles also spread, "gassing up" can be done at home, supplanting oil companies. With producer and user as one, energy gets democratized. Charles Fritts had this vision in the 1880s, as he looked out over the roofscape of New York City. Today, that vision is increasingly coming to fruition.

IMPACT: *Our analysis assumes rooftop solar PV will grow from .4 percent of electricity generation globally to 7 percent by 2050. That growth can avoid 16.4 gigatons of emissions. Implementation costs continue to decrease. Operating costs, will save $2.97 trillion in home energy costs over thirty years.*

WIND TURBINES (OFFSHORE)

#22
RANK BY 2050

14.1 GT
REDUCED CO2-eq

$542B
NET FIRST COST

$763B
NET OPERATIONAL SAVINGS

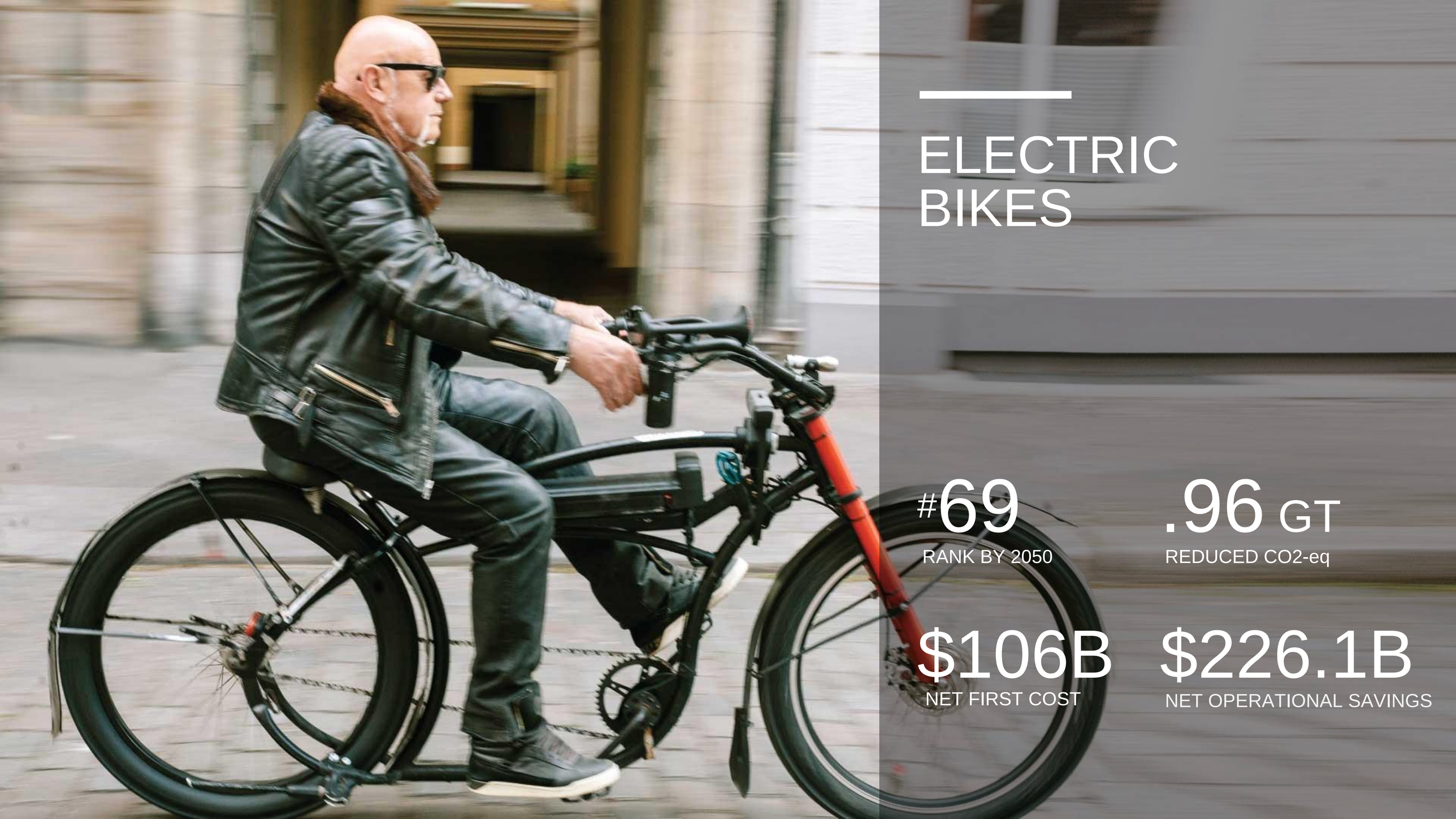
ROOFTOP SOLAR

#10
RANK BY 2050

24.6 GT
REDUCED CO2 -eq

$453B
NET FIRST COST

$3.46T
NET OPERATIONAL SAVINGS



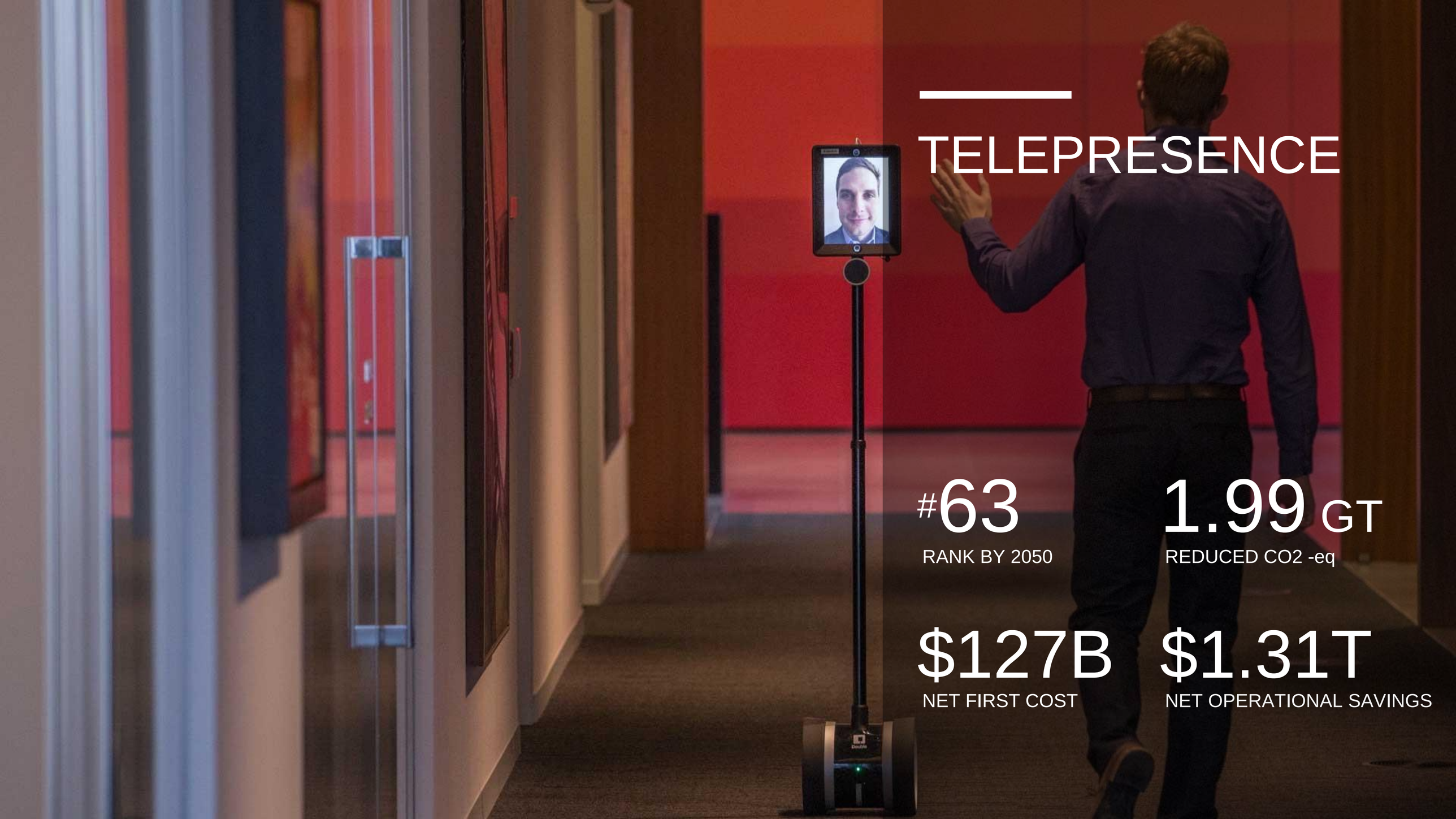
ELECTRIC BIKES

#69
RANK BY 2050

.96 GT
REDUCED CO2-eq

$106B
NET FIRST COST

$226.1B
NET OPERATIONAL SAVINGS



TELEPRESENCE

#63
RANK BY 2050

1.99 GT
REDUCED CO2 -eq

$127B
NET FIRST COST

$1.31T
NET OPERATIONAL SAVINGS

COASTAL WETLANDS

#52
RANK BY 2050

3.19 GT
REDUCED CO2 -eq

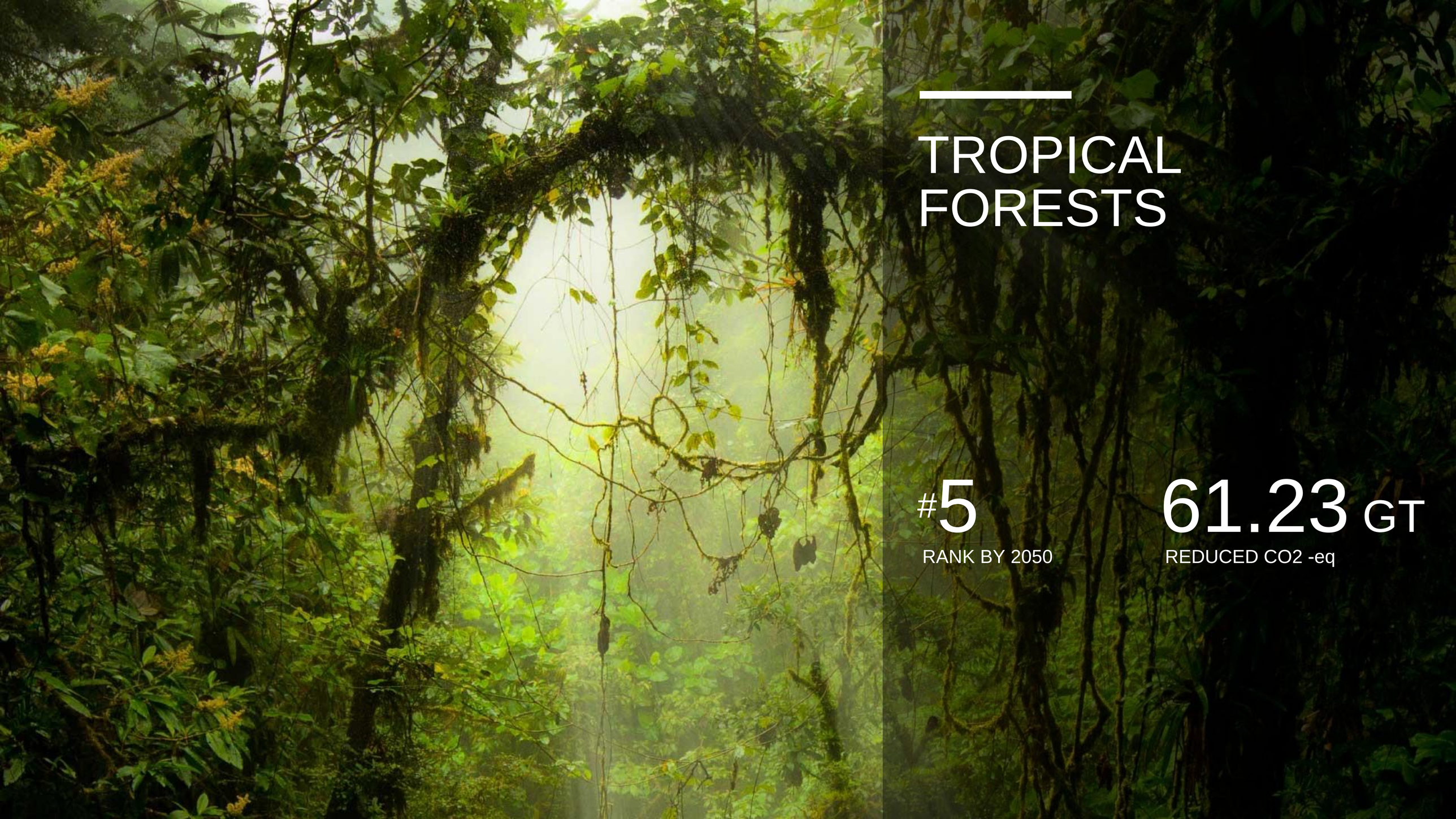
53.34 GT
CO2 PROTECTED

FOREST PROTECTION

#38
RANK BY 2050

6.2 GT
REDUCED CO2 -eq

896.2 GT
CO2 -eq PROTECTED



TROPICAL FORESTS

#5

RANK BY 2050

61.23 GT

REDUCED CO2 -eq

REGENERATIVE AGRICULTURE

#11
RANK BY 2050

23.15 GT
REDUCED CO2 -eq

$57.2B
NET FIRST COST

$1.93T
NET OPERATIONAL SAVINGS

MANAGED GRAZING

#19
RANK BY 2050

16.34 GT
REDUCED CO2 -eq

$50.5B
NET FIRST COST

$735.3B
NET OPERATIONAL SAVINGS

REDUCED FOOD WASTE

#3
RANK BY 2050

70.53 GT
REDUCED CO2 -eq

PLANT-RICH DIET

#4

RANK BY 2050

66.11 GT

REDUCED CO2 -eq

EDUCATING GIRLS

#6

RANK BY 2050

59.60 GT

REDUCED CO2

FAMILY PLANNING

#7

RANK BY 2050

59.60 GT

REDUCED CO2 -eq

TOP 20

RANK	SOLUTION	SECTOR	REDUCED CO2
1	Refrigeration	Materials	89.74 GT
2	Wind Turbines (Onshore)	Energy	84.60 GT
3	Reduced Food Waste	Food	70.53 GT
4	Plant-Rich Diet	Food	66.11 GT
5	Tropical Forests	Land Use	61.23 GT
6	Educating Girls	Women and Girls	59.60 GT
7	Family Planning	Women and Girls	59.60 GT
8	Solar Farms	Energy	36.90 GT
9	Silvopasture	Food	31.19 GT
10	Rooftop Solar	Energy	24.60 GT
11	Regenerative Agriculture	Food	23.15 GT
12	Temperate Forest	Land Use	22.61 GT
13	Peatlands	Land Use	21.57 GT
14	Tropical Staple Tree Crops	Food	20.19 GT
15	Afforestation	Land Use	18.06 GT
16	Conservation Agriculture	Food	17.35 GT
17	Tree Intercropping	Food	17.20 GT
18	Geothermal	Energy	16.60 GT
19	Managed Grazing	Food	16.34 GT
20	Nuclear	Energy	16.09 GT

TOP 20

Materials is only one, but top solution

RANK	SOLUTION	SECTOR	REDUCED CO2
1	Refrigeration	Materials	89.74 GT
2	Wind Turbines (Onshore)	Energy	84.60 GT
3	Reduced Food Waste	Food	70.53 GT
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18	Geothermal	Energy	16.60 GT
19	Managed Grazing	Food	16.34 GT
20	Nuclear	Energy	16.09 GT

TOP 20

Electricity Generation is only 5 of top 20

RANK	SOLUTION	SECTOR	REDUCED CO2
1	Refrigerant Management	Materials	89.74 GT
2	Wind Turbines (Onshore)	Energy	84.60 GT
3	Reduced Food Waste	Food	70.53 GT
4	Plant-Rich Diet	Food	66.11 GT
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17	Tree Intercropping	Food	17.20 GT
18	Geothermal	Energy	16.60 GT
19	Managed Grazing	Food	16.34 GT
20	Nuclear	Energy	16.09 GT

TOP 20

Food is 8 of top 20

RANK	SOLUTION	SECTOR	REDUCED CO2
1	Refrigerant Management	Materials	89.74 GT
2	Wind Turbines (Onshore)	Energy	84.60 GT
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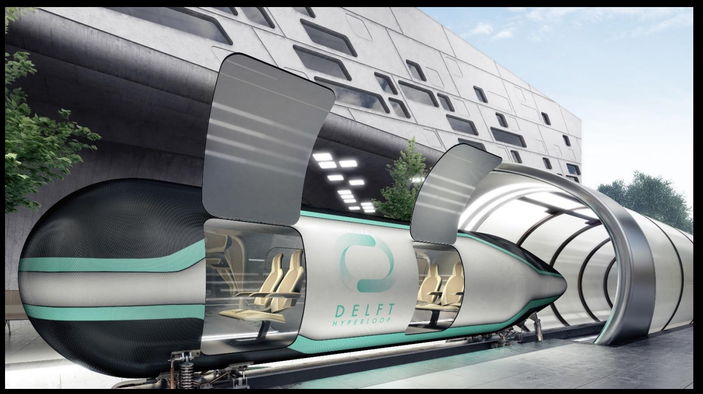
19	Managed Grazing	Food	16.34 GT
20	Nuclear	Energy	16.09 GT

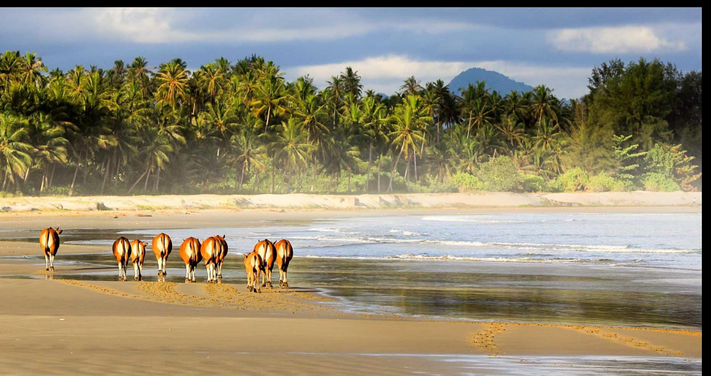
Coming Attractions

HYPERLOOP



ARTIFICIAL LEAF

IMPROVED LIVESTOCK FEED



AUTONOMOUS VEHICLES

DIRECT AIR CAPTURE

ENHANCED WEATHERING

INDUSTRIAL HEMP

INTENSIVE SILVOPASTURE

LIVING BUILDINGS

MICROBIAL FARMING

OCEAN FARMING

PASTURE CROPPING

PERRENIAL CROPS

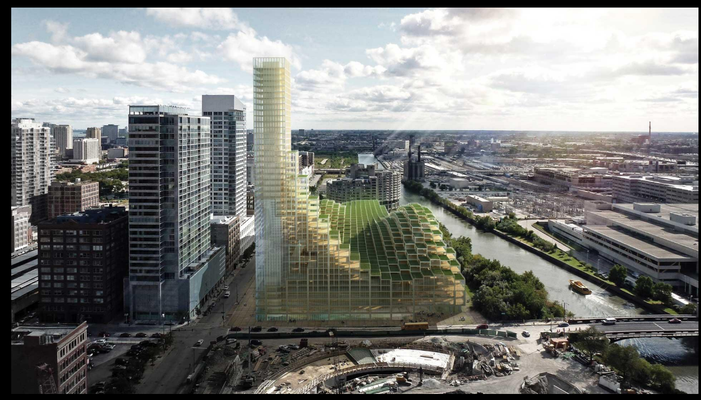
REPOPULATING THE MAMMOTH STEPPE

SMART GRIDS

SMART HIGHWAYS

SOID-STATE WAVE ENERGY

BUILDING WITH WOOD

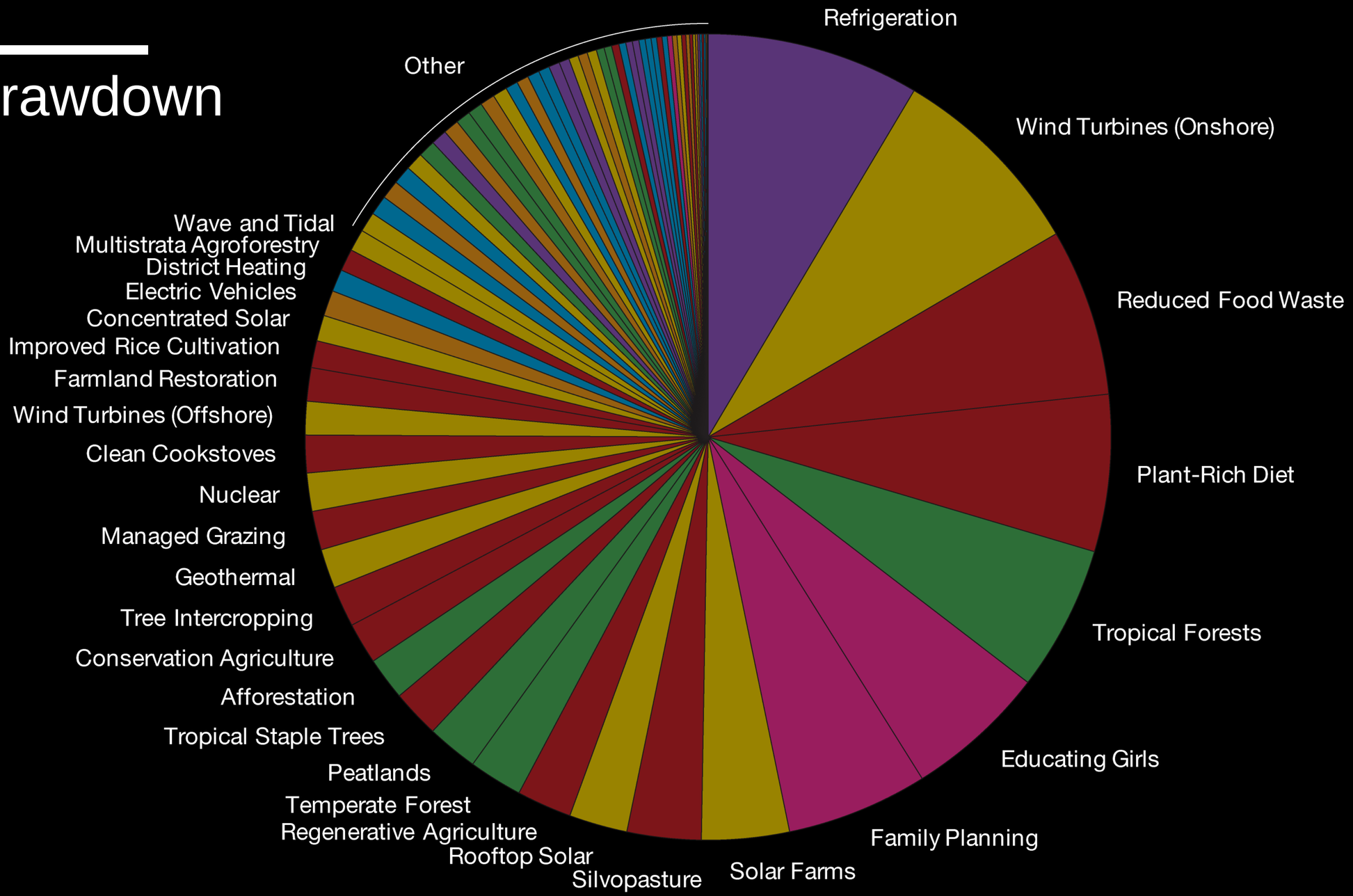


HYDROGEN-BORON FUSION

MARINE PERMACULTURE

Is Drawdown possible by 2050?

Drawdown


Refrigeration
Wind Turbines (Onshore)
Reduced Food Waste
Plant-Rich Diet
Tropical Forests
Educating Girls
Family Planning
Solar Farms
Silvopasture
Rooftop Solar
Regenerative Agriculture
Temperate Forest
Peatlands
Tropical Staple Trees
Afforestation
Conservation Agriculture
Tree Intercropping
Geothermal
Managed Grazing
Nuclear
Clean Cookstoves
Wind Turbines (Offshore)
Farmland Restoration
Improved Rice Cultivation
Concentrated Solar
Electric Vehicles
District Heating
Multistrata Agroforestry
Wave and Tidal
Other

DRAWDOWN

Contact us at:
research@drawdown.org

What’s next?

Ongoing Work

To ensure our work remains meaningful and useful to current and future audiences, all data must be continually **monitored, refreshed, updated, and corrected** when better data arises.

Project Drawdown will continue to act as a **clearing house for the status of solutions.**

Research Phase 2

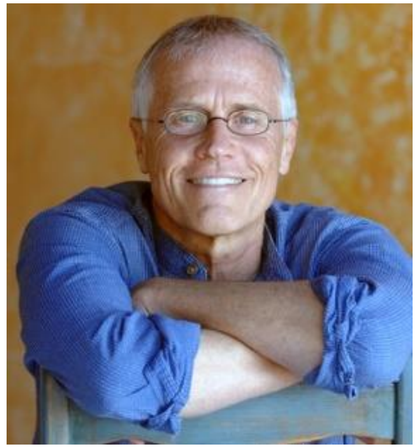
The next phase of our work is to undertake research related directly to the goals of **economic and ecological regeneration at regional, country, and local scales.**

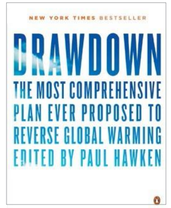
- Perform **collaborative research and modeling** evaluating Drawdown solutions within the contexts of defined boundaries.
- A new version of the model will be developed to take into consideration **possible accelerators** of adoption.
- **Incorporate context-specific data –** including price variations, sequestration rates, capacity factors, etc.
- **Map results to social and economic indicators** most relevant to decision-makers at scale.

COMMUNICATIONS

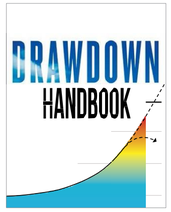
Publications Research and communications are the two legs upon which Drawdown stands and moves

Communications takes many forms: publications, social media, documentary(s), TV series, short form videos for digital media, short form videos for curriculum, teaching guides, handbooks, and more.





Drawdown—The Most Comprehensive Plan Ever Proposed to Reverse Global Warming



Drawdown Handbook

This is "*Drawdown* for Dummies" or the Reader's Digest version, intended to be a more digestible and less expensive publication that will help spread our work and message beyond existing *Drawdown* audiences.

D2 – Coming Attractions

This version of *Drawdown* will be a follow-on book that will codify and bring to life 60-80 more solutions that are taking hold, as well as the people and organizations behind them. D2 will include "back of the envelop" models, offering ranges of possible emissions reductions for each solution.

PARTNERSHIPS

The Drawdown Challenge Working Group began the first set of student-orientated challenges in October, 2017, with the public site planned to be launched on January 1, 2018.

Drawdown Challenge partners:

NET IMPACT

Northwest Earth Institute
DISCOVER CHANGE, TOGETHER.

turninggreen

The Drawdown Coalition

The Drawdown Coalition is the fulcrum upon which our work becomes actionable and serves to accelerate the implementation of solutions globally.

This global Coalition is comprised of individuals and organizations utilizing Drawdown as a platform for engaging their communities and constituencies.

Partnership within the Coalition is based on three principles:

1) a common agenda centered on **reversing global warming** through solutions-focused, data-rich communications and implementation strategies;

2) willingness to **work collaboratively** within the Coalition through shared learning, co-creation, and mutual support; and

3) a **shared measurement and feedback** system through our ongoing research program.

PARTNERSHIPS

Working groups are formed based on the expressed interest of individuals and organizations wanting to take part in making drawdown a reality. There is no limit to the creation of different working groups, or subgroupings; rather, they form organically as more partners come on board.

The following working groups are currently being formed:

Research and Data

Individual experts and research organizations and networks are assisting with our ongoing research efforts. Partners will contribute by collecting and validating data sources, reviewing, developing and improving the Project Drawdown research methodology and models, and sharing resources and new data.

Higher Education Curriculum

Higher and mid-level education instructors and organizations are developing educational tools, lesson plans, syllabi, etc. for teaching grammar, high school, undergraduate and graduate level courses related to Drawdown.

The Drawdown Challenge

Based on the gamification of drawdown actions and solution implementation, organizations engage their constituents by inviting them to participate in structured programs that provide a blueprint for their actions with the purpose of educating participants and having contributors educate others about Drawdown solutions.

Local Communities and Governments

Community organizations and governments are co-developing Drawdown Action Plans relevant to local contexts.

Solution Implementers

Organizations and companies that are implementing solutions on the ground can profile their work, share resources, and connect with other Coalition partners through this common portal.

Drawdown Funds

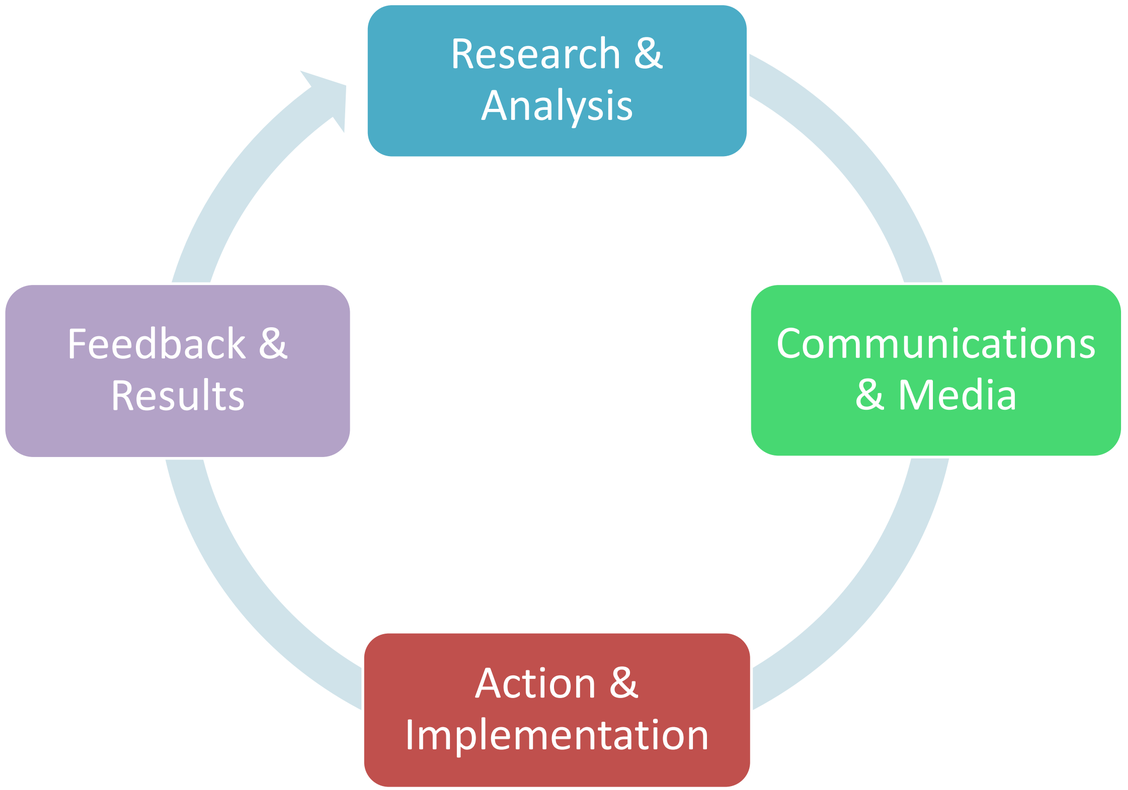
Philanthropic and investment groups are seeking to establish funds to provide capital in support of solution projects globally. This working group aims to pool expertise and share information to reduce risk and maximize impact.

Content Creators

Artists, designers, curators and data visualizers are keen to offer their skills to develop multimedia, data visualizations and infographics based on drawdown. Resulting materials will be shared and under creative common license.

THE DRAWDOWN MODEL

A virtuous cycle of collaborative research, communication, and action – built on the principles of collective impact.



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