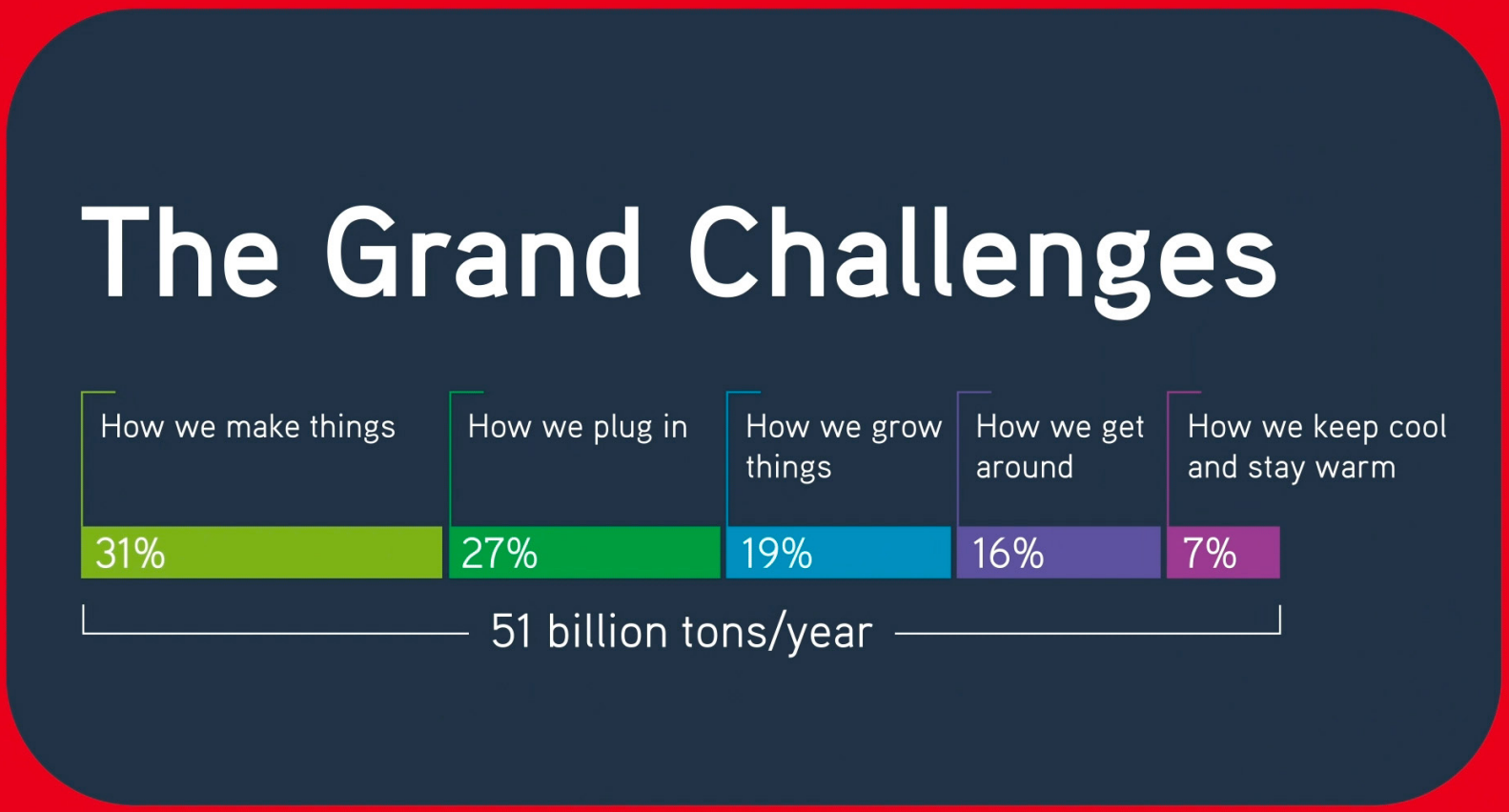

Introduction to the Grand Challenges

Human-caused climate change is having a major impact on our planet, but there is still plenty we can do to prevent the worst of it.

0:09

Narrator appears on screen; line graphs showing increases in both global atmospheric carbon dioxide and global temperatures; chart showing the percentage each grand challenge makes up of the whole

51 billion, 51 billion tons, to be exact. Each year, humanity releases 51 billion tons of greenhouse gases into Earth's atmosphere.

This huge amount of additional greenhouse gases, mostly carbon dioxide, means that our planet retains more heat. This in turn, means higher global temperatures.

Where do these 51 billion tons of greenhouse gases come from? Unfortunately, almost everything we do as humans releases greenhouse gases. From turning on a light switch to flying thousands of miles across a continent; it all adds to that 51 billion tons, and makes climate change worse.

The 51 billion tons of emissions we produce each year come from five major categories, that we call Grand Challenges. The five Grand Challenges are: how we make things, how we plug in, how we grow things, how we get around, and how we keep cool and stay warm.

1:09

Graph showing global energy consumption by source with upward trends, text above chart: 1 terawatt = 1 trillion watts; images of the Los Angeles skyline, coal power plant, solar panels

Today, electricity is almost everywhere, and we use a lot of it. In 2019, Humanity consumed 160,000 terawatt hours of electricity, and our usage is still climbing.

The way we generate power accounts for 27% of the 51 billion tons of greenhouse gases humans produce every year. That's why, how we plug in, is our first grand challenge. In fact, how we plug in, might be the most important grand challenge.

You see, all the processes we describe in other grand challenges use electricity. We use it to build, to move around, to grow our food, and to run our air conditioning and heating.

So, if we're going to decarbonize those human activities, we need to produce more clean electricity. How can we do this? Well, electricity can be generated in lots of different ways.

For example, let's look at the city of Los Angeles, one of the largest cities in North America, and where I live!

Most of LA's power comes from coal fired plants, many of them decades old. Some of the power comes from newer sources, including solar projects- both massive solar facilities- like this one, and smaller panels on the roofs of people's houses, like this.

There are also a dozen wind plants, one geothermal plant, and a nuclear power generating station.

2:26

Images of the Hoover Dam, pollution from a coal plant; pie chart of global electricity generation sources; images of large construction projects, NYC skyline

A small amount comes from a landfill, where gases from rotting garbage, are turned into fuels. And most of the rest comes from the Hoover Dam, a massive hydroelectric plant near Las Vegas.

It's the coal plants that are the biggest problem, in the case of Los Angeles. When you generate electricity by burning fossil fuels, like at these coal plants, you produce a lot of carbon emissions.

Unfortunately, today fossil fuels account for about two thirds of global electricity generation. If we're going to get to zero, this needs to change.

Humans are making a lot of stuff, and I don't just mean plastic straws and plush Pokémon toys, I mean big stuff!

The global population is growing, I mean you probably knew that. But did you know that by 2060 we'll have double the number of buildings on Earth?

Here's what that means, on a global scale we're going to be building the equivalent of New York City every month, for the next 40 years. That's 480 additional New Yorks!

Most of that growth will be concentrated in places like China, India, and Nigeria, where millions of people are pulling themselves out of poverty and migrating to cities.

3:39

Images of cement manufacturing plants; textbox: Cement is the ingredient in concrete that makes everything stick together

That's not a problem, it's a good thing. But, you know what is a big problem? Almost all the stuff we humans make, produces some greenhouse gas, but concrete and steel produce a lot of it.

Cement, the main ingredient in concrete, is probably the biggest offender.

Cement production alone accounts for 8% of the carbon we put into the atmosphere, each year. Building 480- new- New York Cities, in the next 40 years is going to require a lot of concrete.

Finding carbon-free methods to make the cement needed for all that concrete, is going to be very important. And that effort is a big part of grand challenge number two, how we make things.

Altogether, making things is responsible for 31% of greenhouse gas emissions, almost a third of all global emissions. That's the largest percentage of any of the five grand challenges.

How does making things generate greenhouse gases? There are three main ways.

4:37

Textbox listing three sources of greenhouse gas from manufacturing: 1. Electrical generation 2. Heat generation 3. Chemical reactions; images of smoke from fossil fuels, steel production, raw ingredients being burned; graphic of U.S. flag alongside cement production stats

First, it takes a lot of electricity to make stuff. Using electrical power in and of itself isn't a problem, but how that power is generated matters a great deal.

If electricity used to make materials comes from renewable sources, that's fine, but today most of it comes from burning fossil fuels, which produces lots of greenhouse gas.

Second, we need extreme heat to make cement and steel. For example, steel production requires melting iron at 3000 degrees Fahrenheit, that produces a lot of carbon.

Finally, the chemical reactions that turn raw ingredients into steel, or glass, or cement, also directly produce carbon dioxide.

We use a lot of cement! In the United States, we make more than 96 million tons of cement a year, that's 600 pounds for every person.

In the 20th century, the United States built a lot of new stuff as its population grew. Constructing new cities and massive infrastructure projects; concrete was a big part of that expansion.

From 1901 to 2000, the United States made 4.3 billion tons of cement; that sounds like a lot, right?

5:48

Graphics of flags for China and U.S. with different bar lengths to compare cement production, China has a significantly longer bar; image of worker standing in freshly poured cement

Well now, in the 21st century, China is undertaking its own expansion, building new power plants and urban infrastructure.

In the 15 years, from 2001 to 2016, China made 25.8 billion tons of cement, six times more than the United States made in the entire 20th century.

The challenge starts with a simple equation: limestone, plus heat, equals calcium oxide, plus carbon dioxide.

The calcium oxide in this equation is the cement we need; the carbon dioxide is a byproduct that's released into the atmosphere when you make that cement.

If you make one ton of cement, you produce one ton of carbon dioxide. This simple fact is what makes this innovation pathway so daunting.

So, if making stuff emits so much greenhouse gas, why don't we just stop making stuff? Sure, we can make less stuff, but even that drastic step wouldn't be enough.

6:44

Images of plastic bags and straws, homes, a bridge, techs installing fiber optics, crops being plowed, meat grinder, herd of cattle

Remember, we're not just talking about consumer goods, like single-use plastic bags or plastic straws. The big emitters, especially concrete and steel, are used for things people need.

That includes buildings to live and work in, bridges and roads to get to places, and internet cables to connect us to each other.

So, making less stuff, isn't really the solution. We also need innovations that let us make the big stuff, without putting as much greenhouse gas into the atmosphere.

The way we grow crops, raise cattle, and make hamburgers, is also one of the primary drivers of climate change.

This problem is at the heart of grand challenge number three, how we grow things, and it's responsible for 19% of all emissions every year. And, as global populations continue to rise, we'll need to grow even more food, about 70% more.

That, in turn, means more greenhouse gas emissions and more climate related disasters, like droughts and fires, that threaten our food supply.

That is, unless we can change the methods we use to grow our food.

7:49

Images of livestock, deforestation, woman shopping the dairy aisle, food waste; bar graph comparing CO2 emissions, Cattle (if it were a country) is the third largest

Total emissions from how we grow things are split into four categories: livestock, crop production, land-use, and food waste. About a third, 31%, comes from livestock and fisheries; raising animals creates a lot of greenhouse gases.

First, there's all that land that used to be forests or other biomes, which absorbed carbon and are now being used for pasturing animals instead. Processing and transporting meat, eggs, and dairy, also contribute to livestock emissions.

And, livestock themselves create a lot of greenhouse gases, especially methane, which comes from the way some animals, like cattle, digest their food. Cow burps and farts, but mostly the burps, are a huge source of greenhouse gas.

If cows were a country, they would be the third largest emitter, behind only China and the United States. Another third, 27%, comes from the way we grow all the plants we eat. About a quarter, 24%, is from land-use, mostly from when we cut down forests to make fields to grow our food.

The rest is mainly from processing, transporting, and packaging food; including food waste. All of these activities contribute to greenhouse gas emissions, making climate change worse and making our food systems less secure.

9:04

Images of trucks crossing toll gates, large cargo ship, group in a car; clips of the various modes of transportation

Look around the room you're in, unless you're taking this class in the middle of some wilderness, most of the stuff in your room was transported there from somewhere else.

And, I'm willing to bet that a lot of it, like food, clothes, and furniture, was carried by a vehicle that ran on fossil fuels. The same goes for you, and any other people in your room.

You probably got to school in a vehicle that burned fossil fuels. In the world today, there are more than 1 billion passenger cars in operation, and we make more each year.

Of course, it's not a bad thing that more people have access to transportation. Our planes, trains, and automobiles- not to mention our trucks and cargo ships- get us, and the products we depend on, from place to place.

But, the increasing number of vehicles is a huge problem for climate change, and that's a good description of grand challenge number four, how we get around.

10:01

Clips of fast moving traffic; pie chart showing percentage each transportation category makes up of emissions

The ways in which we move people, and things, contribute about 16% of the 51 billion tons of greenhouse gases, that humans produce around the world each year. That's a pretty hefty chunk, and here in the United States, transportation emits more greenhouse gases than any other grand challenge.

This should serve as a warning, as nations get richer, transportation expands. So, any increase in global wealth will just lead to more transportation emissions, and make climate change much worse. That is, unless we make some changes.

What are these changes? Well, right now, lots of different kinds of vehicles create emissions. Personal vehicles, like cars, SUVs, and motorcycles, account for almost half the carbon produced by transportation.

Commercial vehicles, everything from garbage trucks to buses, make up another 30%. Then, big ships- cargo and cruise ships- and airplanes, each make up another 10%. Finally, there's about 3% from miscellaneous vehicles, mostly trains.

11:02

Graphic visual showing a gallon of gasoline, equal sign, and stacks of dynamite; bar charts showing steady increases in heat wave frequency and intensity over time

What do these vehicles all have in common? They all use some sort of fossil fuel. Fossil fuels contain a lot of energy, and I mean a lot!

A single gallon of gasoline holds as much energy as 130 sticks of dynamite, and it's cheap. We might complain about gasoline prices, but a gallon of gas, is still comparable to a gallon of milk or orange juice.

So we get a lot of energy from gasoline, for very little money; but, there's a hidden cost. Burning fossil fuels, like gasoline, releases carbon into the air each time you step on the gas pedal.

Climate change is making extreme heat and extreme cold events more common all around the world, and a lot of people lack access to sufficient heating and cooling.

But, I have some good news, and some bad news; unfortunately, the good news is also the bad news.

As long as global poverty rates decrease, more people will have access to technologies like air conditioning, that's a good thing. Those people will live more comfortably and can escape extreme heat events, but it's also a problem.

12:08

Clip of HVAC unit with smoking wires; images of air conditioner, wood burning in a fireplace

The methods we use to heat and cool our buildings are a significant contributor to greenhouse gas emissions. The very thing we're doing to survive extreme temperatures, are making those temperatures worse and more frequent.

Let's start with the numbers, keeping cool and staying warm accounts for about 7% of the 51 billion tons of carbon emissions that humans produce every year.

Some of that comes from the energy we use to power air conditioners. Some comes from leaked refrigerants that air conditioners use to make our houses cold. Some comes directly from fuels we burn to heat our homes, like gas and wood in fireplaces.

Now, 7% might seem small, compared to other sources of greenhouse gas, but we have to consider every source of emissions if we want to get to net zero. And heating and cooling are set to become more important in the future.

12:56

Column chart showing percentage of households with air conditioning in various countries; images of the devastating effects of climate change globally, refugees migrating, village of threadbare makeshift dwellings

As the global climate gets more variable, parts of the world that never needed air conditioning or heating before will become desperate for them.

As a result, global demand for cooling is expected to triple by 2050, if that happens, air conditioning alone will consume as much electricity as all of China and India combined do today.

Climate change is a factor in the hurricanes hitting the East and Gulf coasts. It's a factor in the heat waves and fires damaging the Pacific Northwest.

And both at home and around the world, the most vulnerable people, are often the ones who suffer the worst effects.

In fact, we're facing a future in which refugees from climate change will be increasingly common. As whole populations are forced to abandon their homes, in the face of drought, flooding, and other climate disasters.

We can't leave it up to someone else, or some other generation, to face this challenge. Now is our time to get serious about climate change, and discover each of our individual roles in getting from 51 billion to zero.