# The Global Energy Challenge

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#### **Michael Greenstone**

Milton Friedman Distinguished Professor in Economics University of Chicago

Director Becker Friedman Institute at the University of Chicago

Director Energy Policy Institute at the University of Chicago



#### The Global Energy Challenge

How can we ensure that people around the world have access to the reliable, affordable, energy needed for economic growth and human development without putting the current environment at risk or causing disruptive climate change?





# Seven Facts that Explain the Difficult Balance between Energy and Growth

**1. Energy is Critical for Growth** 



### **Energy is Critical for Growth**



- There is no economic growth without energy.
- Continued growth in energy demand per capita is critical for improving quality of life in emerging economies.
- In this sense, expanded energy access is not only desirable, it is fundamentally imperative and inevitable.



# Seven Facts that Explain the Difficult Balance between Energy and Growth

- 1. Energy is Critical for Growth
- 2. Energy Access is a Major Problem



### **Energy Access is a Major Problem**

#### Per Capita Electricity Consumption and Population, 2021



- Per capita energy consumption in emerging economies remains significantly lower than developed world levels.
- According to the International Energy Agency (2021), nearly 770 million people globally lack access to reliable electricity
- It takes 131 kWh to use a 60 watt light bulb for 6 hours per day for a full year.



# Seven Facts that Explain the Difficult Balance between Energy and Growth

- Energy is Critical for Growth
  Energy Access is a Major Problem
- 3. Demand will Grow Rapidly in Emerging Economies



# Demand will grow rapidly in emerging economies



- Global energy demand is set to grow by one-fourth between now and 2050.
- Fully 100 percent of expected growth will occur in emerging market economies, especially in Asia.
- China and India are expected to account for about half of global energy demand growth between today and 2050 based on business as usual.
- Energy demand in Africa will grow by 142 percent between now and 2050.



# Seven Facts that Explain the Difficult Balance between Energy and Growth

- 1. Energy is Critical for Growth
- 2. Energy Access is a Major Problem
- Demand will Grow Rapidly in Emerging Economies
- 4. Fossil Fuels are Expected to meet much of this Growth



### Fossil Fuels will meet Much of this Growth

#### World Total Energy Supply, 2010 - 2050



 > Based on policies in place in 2021, the International Energy Agency expects non-renewables to supply 66 percent of world primary energy in 2050, compared to 79 percent in 2020.



### Why? Fossil Fuels are Inexpensive in Power Sector

EPIC analysis based on data from the Department of Energy. Existing coal excludes capital cost.

#### Levelized Cost of Energy, United States



Current Baseload Renewa

Renewables with Battery Back-up



### ...and Fossil Fuels are Inexpensive in Transportation Too

Breakeven NPV of Owning an Internal Combustion Engine versus an Electric Vehicle with 250 Miles of Range



Source: Covert, Greenstone, and Knittel, "Will We Ever Stop Using Fossil Fuels?"



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- The world has consistently held approximately 50 years worth of natural gas reserves for over the same time period, meaning annual reserve additions have roughly equaled production.
- Coal reserves are currently equal to 132 years of consumption—down significantly from 1995, but still ample.



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- 5. Fossil Fuels Increase Pollution that Shortens Lives

5.9 billion peoplecurrently live in areasthat exceed the 2020WHO safe guidelinefor small particulatepollution.



Particulate pollution overwhelmingly comes from energy use.

Where does PM Pollution Come From?

	25%	Vehicles
•	20%	Household Wood and Coal Burning
	15%	Power Plants and Industry
•	22%	Other Human Activity
	18%	Natural Sources

Revisiting the Impact of Sustained Exposure to Air Pollution on Life Expectancy from China's Huai River Policy

Ebenstein, Fan, Greenstone, He, and Zhou (2017)

THE UNIVERSITY OF CHICAGO



### China's Huai River Winter Heating Policy

- 1) Established during the planning period, 1950-80.
- 2) Municipal heating systems built in cities to provide subsidized heating to homes each winter (e.g. Nov 15 to Mar 15 in Beijing). Heat generated by coal boilers.
- 3) Due to budget limitations, only built municipal heating systems in cities north of Huai River-Qinling Mountains line.
  - » Only in recent years has municipal heating started to emerge in southern cities

#### The Dividing Line

The Huai River forms the dividing line between regions with heavy coal-fired home heating and regions with little to no use of such boilers.



#### The Boiler Heating System

Subsidized coal is burned to heat water, often in a boiler housed in a building. The combusted coal emits high levels of soot and particulate matter.





### Pollution is 40% Higher North of the River



#### PM<sub>10</sub> Emissions North and South of the Huai River

Degrees North of the Huai River Boundary



### Life Expectancy is about 3 Years Lower



#### Life Expectancy North and South of the Huai River

Degrees North of the Huai River Boundary

Source: Ebenstein et al (2017)

### The Air Quality Life Index

An interactive platform that connects people anywhere in the world with data on how particulate pollution impacts their life expectancy.



### PM Pollution Damages Are Highly Unequal Across the World



In India, reducing  $PM_{2.5}$  to national standards could increase life expectancy by 1.9 years; reducing to the WHO guideline could increase it by 5.2 years.





# Particulate matter air pollution is the single greatest external threat to human health globally.



Data on other causes and risks of mortality are from the Global Burden of Disease (2016).



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- Fossil Fuels Increase Pollution that Shortens Lives
- 6. Fossil Fuels are Causing Climate Change, and its Projected Impacts are Large and Heterogeneous



### Impacts to the US are Minimal

#### Estimated Impact of Temperature on Mortality



- This figure presents the estimated mortality impact of a day in one of seven daily temperate bins relative to a day in the 70-74 °F bin.
- There is a clear relationship between increased temperature and mortality, though the actual impacts are minimal for Americans.

Daily Average Temperature



### Impacts to the US are Minimal

#### Estimated Impact of Temperature on Mortality



 The relationship in the United States is negligible if we zoom out to a scale where large changes would indicate much more dramatic impacts.



### Impacts to India are Large

#### Estimated Impact of Temperature on Mortality



- The relationship in the United States is negligible if we zoom out to a scale where large changes would indicate much more dramatic impacts.
- However, even at this scale, the relationship in India is today quite substantial, indicating that the population there is highly vulnerable to shifts in temperature.

Daily Average Temperature



### The Global Distribution of Climate Mortality Damages is Highly Unequal, 2100



Source: Carleton et. al. 2021


# The Impact of Climate Change in 2100 is Comparable to Contemporary Leading Causes of Death





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- 7. The Climate Challenge is Substantial and the Global Energy Challenge Makes it Harder



## 21st Century Emissions and Warming Projections





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## Emissions to Keep Temperature Rise Below 2C



































Emissions to Keep Temperature Rise Below 2C



## ... And Inflation Reduction Act is Only a Start towards US Goals





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Source: US Energy Information Administration





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Section 2

# **Three Key Solutions**

1. Price Energy at its Full Social Cost



## **Fossil Fuels Are Mispriced**



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- This is especially true if we limit our analysis to system configurations capable of providing baseload power.



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- The story gets more interesting if we begin to include external costs, such as the climate impacts of fossil fuels as well as the particulate impacts of fuel combustion.



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Source: State and Trends of Carbon Pricing 2022, The World Bank

# Map of Carbon Taxes and ETSs





# **Global Carbon Pricing is Rising but Highly Inconsistent**

### Average Price of All Carbon (Including un-priced)





## **Current US Policy is Piecemeal and Often Expensive**

Cash for Clunkers Weatherization Assistance Program CAFE Standards Wind Energy Subsidies Renewable Portfolio Standards **Renewable Fuel Subsidies** Livestock Management Policies Reduced Federal Coal Leasing Agricultural Emissions Policies Methane Flaring Reduction Clean Power Plan Reforestation **Direct Air Capture** Build Back Better Tax Incentives -200



🕨 Low 🛛 🔵 High



## **Current US Policy is Piecemeal and Often Expensive**

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Source: EPIC analysis with data from Gillingham and Stock (2018)

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High

Low



# Are Distributional Concerns Preventing Carbon Pricing?

#### Consider a carbon tax scenario that would

- price carbon at roughly \$52 (in 2018 dollars) per ton in 2020
- increase at a rate of about 2% per year (adjusted for inflation)

#### In this scenario, over the 2020-2029 period,

- the carbon tax receipts would be \$2.8 trillion (in 2018 dollars)
- the net federal revenue would increase by about \$2.1 trillion (in 2018 dollars)

#### Consider the following revenue recycling options

- **Deficit reduction:** devote all the increased carbon tax revenue toward reducing the federal deficit
- Per-capita household rebate: return carbon tax revenues by providing per capita rebates to households, with adjustment based on the composition of the tax filing unit



# What's the distribution implication of a carbon tax?

Tax change as a percent of pretax income. Fully phased-in effect, 2025.





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## **Three Key Solutions**

1. Price Energy at its Full Social Cost

- 2. Invest in Innovation
  - a) Policy Innovation



## Non-Compliance With Environmental Standards Is Common Practice



- In early 2017, China's Ministry of Environmental Protection examined whether businesses were meeting environmental standards for controlling pollution
  - > Inspected 20,000 businesses across 28 cities in northern China
- 2) Inspectors found that nearly 70% of these businesses failed to meet standards
  - > Violations included lack of pollution control equipment, excessive emissions, and lack of relevant certifications



#### Case Study: An Experiment to Improve Environmental Regulation in Gujarat

Gujarat is the most industrialized state in India and among its most heavily polluted. The Gujarat Pollution Control Board regulates more than 20,000 industrial plants using third-party audits.



## The Policy Status Quo

- 1) India has strict environmental laws on the books
  - » Yet, pollution levels are high
- 2) Gujarat uses third-party audits to enforce environmental regulations
  - » Polluters select and pay their auditors
- 3) Working with the Gujarat Pollution Control Board, we designed an intervention to break this conflict of interest
  - » We divided plants into a control group and a treatment group
  - » The control group continued the status quo approach to audits
  - » In the treatment group, polluters paid into a central fund, which randomly assigned auditors to the plants



#### Audit Readings for Suspended Particulate Matter





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### What happened to pollution?

The reformed auditing program caused plants to reduce their pollution emissions by 28 percent.



## **Research and Policy Partnership**

"Our partnership proves the success of innovative, evidencebased approaches to policymaking and is a model for how researchers and policymakers can make a big difference by working together."

Hardik Shah, Member Secretary of the Gujarat Pollution Control Board



## **Three Key Solutions**

- 1. Price Energy at its Full Social Cost
- 2. Invest in Innovation
  - b) Technical Innovation



## Innovation is Causing Rapid Change in Energy



Average Construction Cost (\$/kW of installed

Lithium-ion Battery Pack Price for EV (\$/kWh)



#### There has also been Innovation in Fossil Fuel Recovery

Fractures

Hydraulic fracturing and horizontal drilling have unlocked massive oil and natural gas resources in the United States.



Shale Caprock

Shale with Organic Material

Bedrock

#### Untapped Shale Resources Exist Around the World

Outside North America, China and Argentina have tapped shale deposits, and many other countries have the potential to do so.





## ..and Energy R&D Remains a Small Share of GDP

Energy R&D Share of GDP



 Energy R&D investment in many countries has plummeted from levels reached in the mid-1970s.

Source: IEA



## **Three Key Solutions**

- 1. Price Energy at its Full Social Cost
- 2. Invest in Innovation
- 3. Voluntary Actions

In the absence of significant government action, organizations and individuals are taking action against climate change

## Explosive Demand in Voluntary Carbon Market







Gary Gensler 🤡 @GaryGensler

Today we announced that @SECGov will meet publicly on March 21 to consider staff proposals to mandate climaterisk disclosures by public companies.

Companies and investors alike would benefit from clear rules of the road. Here's why:



# Post-SEC regulation:

VCM demand will accelerate as all US public company emissions come into play.

2,600 million tons of CO2 **Emissions from US Public** Companies



# Supply Side is Broken Voluntary Offsets Have Failed to Deliver

- Limited audit mechanisms to ensure continued effectiveness of voluntary offsets
- Widespread incidents of fraud and greenwashing
- Reliance on forests as an offset mechanism can be counterproductive mismanaged forest growth can cause forest fires. Often less carbon would have been emitted if the trees had been cut down





# Climate Vault is an award-winning, non-profit founded at the University of Chicago.



YOUR PATH TO NET ZERO CLIMATE

CLIMATE VAULT APPROACH YOUR IMPACT

OUR TEAM NEWS

## Carbon Reduction and Removal

The Climate Vault approach is one of the simplest ways to achieve net zero. Rather than trying to estimate the carbon reductions created by planting trees or distributing clean cookstoves, we can measure exactly how much carbon pollution we're preventing, ton by ton.

At Climate Vault, we do this by purchasing carbon permits from cap-and-trade compliance markets and vaulting them so emitters can't use them. Because the number of permits is capped, this decreases the amount of global carbon dioxide pollution allowed by government regulators.

Our purchases are based on how much carbon you're aiming to offset. Whether you're looking to reduce your footprint or get all the way to net zero, we can help you reach your goals quickly. And because we use existing markets, the cost is transparent, and your offset is easily verified. You'll never be left wondering if your efforts created a real impact or not. In fact, your impact goes beyond carbon reductions to support carbon removal.





FOUNDED AT THE UNIVERSITY OF CHICAGO

# Climate Vault's world leading CDR experts

# Leading minds dedicated to evaluating carbon reduction technologies

#### **Ernest Moniz**



Chair, Climate Vault Technology Experts Chamber; Former US Secretary of Energy

Area of Expertise: Technological (physics, energy tech, policy)



Distinguished Institute Professor, Biocomplexity Institute, UVA; Former Under Secretary, USDA

Area of Expertise: Terrestrial (agricultural, policy)

#### John Deutch



Emeritus Institute Professor, MIT Dept. of Chemistry Former Under Secretary DOE

Area of Expertise: Chemistry (energy tech, technology, policy)

#### **Margaret** Leinen



Vice Chancellor for Marine Sciences, Director of Scripps Institution of Oceanography and Dean of the School of Marine Sciences, UCSD

Area of Expertise: Oceans (oceans, climate)

#### **Steve Pacala**



Frederick D. Petrie Professor in Ecology & Evolutionary Biology, Princeton

#### Area of Expertise: Terrestrial (Global carbon cycles, biology, ecology)

#### Daniel Schrag



Professor of Environmental Science and Engineering, Director of the Center for the Environment, Harvard;

Area of Expertise: Technological (Geochemistry, climatology, carbon capture and storage)





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## Awards and Accreditations







# Demonstrated success since May 2021 launch









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