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Senate Energy Committee Issues Testimony From University of Texas-Austin's Bureau of Economic Geology Director Tinker

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Body

The Senate Energy and Natural Resources Committee issued the following testimony by Scott W. Tinker, director of the ***Bureau of Economic Geology*** at the University of Texas-Austin, at a hearing entitled "Examining Global Climate Trends and Progress in Addressing Climate Change" on Feb. 3, 2021:

We have before us the challenge of providing affordable and reliable energy to grow healthy economies and lift the world from poverty, while at the same time addressing climate change and minimizing damage to land, water, and air.

I believe that I share a common a desire with each of you. To end global poverty, maintain a vibrant U.S. economy and jobs, and reduce human impacts on the broad environment.

I worked in the energy industry for 17 years before coming to the University of Texas 21 years ago. I direct a 250-person research organization that studies global earth resources, environmental impacts, and economic implications.

I formed the non-partisan Switch Energy Alliance and produce documentary films about energy, the environment, and poverty that are used by educators globally.

I have travelled to 65 countries and interacted with governments, industry, academics, and the public. I have witnessed extreme poverty and extreme wealth.

In the supplemental material, I have made twenty energy statements, each with a key graphic and reference source. I have tried to be completely factual, and factually complete.

I'll begin with a few highlights from those statements, followed by a brief discussing on carbon dioxide solutions.

* Global population is ~ 7.7 billion and increasing. We are not evenly distributed.

* The world is becoming urban. Dense cities need dense energy.

* About half of the global population lives on less than $2000 a year. The U.S. individual poverty level is $12,700.

* A successful energy transition must address global energy poverty. Energy won't end poverty, but you can't end poverty without energy.

* Asia represents 55% of global population and since 1965 energy demand grew nearly 14X. Providing affordable energy, while also reducing emissions, must happen in Asia.

* Asia represents 75% of the world's coal electricity generation.

* The coal/gas ratio in China is 20X that is the U.S.

* China continues to build coal power plants at a rapid rate. Coal is an Asian story.

* Solar and wind were the fastest-growing sources of global electricity since 2005 in terms of rate, yet provided 25% of the growth in global electricity demand. Scale matters.

* Natural gas was the fastest-growing source of global electricity generation since 1985.

* China controls global lithium, cobalt, and many other mined resources required for panels, turbines, and batteries, bringing into question energy security and human rights.

* Solar and wind are intermittent and require backup, which adds considerably to levelized cost (LCOE) to the consumer.

* To electrify half of today's global vehicle fleet would require over 3 trillion new batteries every 15 years or so. Mining, manufacturing, and disposing batteries is not "green."

* Coal, oil, nuclear, natural gas, and hydrogen are much denser than biomass, hydro, wind, geothermal, and solar. Energy density matters for environmental impact and cost.

* All forms of energy require significant resources from the earth, and that non-renewable.

Given this context, proposed CO2 solutions must do several things.

* Reduce actual CO2 emissions into our single global atmosphere

* Protect the rest of the environment. Don't rob from nature Peter to pay climate Paul.

* Be affordable, dispatchable, and scalable

* Be deployed in the next two decades

* Protect U.S. security and the U.S. economy

Viable options, in order of U.S. importance and global impact include

* Fuel switching from Coal to Natural Gas, especially in Asia

* U.S. natural gas development and LNG transport are needed to provide natural gas to Asia

* Expand the U.S. Nuclear fleet with next generation technology, streamline permitting and deep borehole disposal

* Dispatchable Nuclear in India and China and small modular reactors in emerging economies

* Efficiency across all U.S. sectors

* Distributed Solar and Wind and in certain settings dispatchable

* Create a world-leading Carbon Capture Utilization and Storage hub in the Gulf of Mexico

* Hydro and Geothermal, where resources are viable

* Build out Hydrogen infrastructure in the U.S.

In summary, natural gas, nuclear, and efficiency are proven to reduce CO2, with a lower overall environmental footprint; are dispatchable, reliable, affordable, and ready today; and preserve industry and grow higher-wage American and global jobs.

Hydro, solar, wind, CCUS, geothermal, and hydrogen have growing roles to play, but significant environmental impacts and costs of their own. Carbon neutral is not always nature neutral.

For transport, improved ICE efficiency; natural gas and fuel cells; and EVs especially in cities will all reduce CO2. Batteries at scale will have an unprecedented mining and landfill disposal impact on the environment, and charging them in Asia is done mostly with coal.

The U.S. can lead through investment in technology, federal and state incentives, and efforts to find scalable, affordable, timely solutions.

Policy makers should resist well-intended efforts to restrict market optionality, which often result in unintended consequences.

Thank you for the opportunity to speak to you today.

Statements about Energy, the Economy, and the Environment

I believe the statements that follow to be both factually correct, and as complete as I can make them, given what I understand today. Time and progress always provide improved clarity. There are links to key sources in the text, and data sources are shown on each graph.

Statement 1. Global population is ~ 7.7 billion and increasing. Population is not evenly distributed. Cities in high income regions such as the U.S. and Europe show up as dense red dots on a global map. In middle to lower income regions such as India, SE Asia, and sub-Saharan Africa, population is very dense, but spread across urban and rural.

https://ourworldindata.org/urbanization

Statement 2. Across most high-income countries, more than 80% of the population live in urban areas. In many low to lower-middle income countries, the majority still live in rural areas. The urban migration is illustrated very well by the U.S., China, and India. The U.S. was wealthy in 1960. With population growth the urban (red) migration continued with rural (blue) remaining flat. China was poor in 1960. With industrialization, the urban (red) population has grown rapidly while the rural population plateaued and fell below urban. India remains poor. With extreme population growth, rural (red) population is still almost double urban (blue). Dense cities require dense energy.

https://ourworldindata.org/urbanization

Statement 3. Affordable, reliable, and scalable energy underpins modern economies. Lack of energy, so called energy poverty, is tied directly to economic poverty. As I have written, this creates a paradox. Energy won't end poverty, but you can't end poverty without energy.

Statement 4. About half of the global population lives on less than $2000 a year. The U.S. poverty level for an individual in 2020 was $12,760, which is over 6X the income of half of the world's population today. The negative economic impacts from COVID-19 will have a detrimental impact on global poverty. Any successful energy transition must address global energy poverty.

Statement 5. Global energy demand has increased 375% since 1965. That growth was led initially by the U.S. and Europe, but eclipsed quickly, and overwhelmingly, by the Asia Pacific with nearly 1400% growth. The rest of the world is just getting started in terms of energy demand.

Statement 6. The global energy mix has been decarbonizing since 1965, when it was dominated by coal (carbon) mostly for power generation, and oil (complex carbon-hydrogen chains) mostly for transportation. Today the energy mix includes significant natural gas (CH_4: mostly hydrogen) and in lesser amounts nuclear, hydro, and emerging solar, wind, biofuels, and geothermal. In 1965 fossil fuels were 94% of the energy mix. In 2019 they are 84%, with natural gas growing over 600% since 1965.

Statement 7. North America, Russia, the Middle East, and Europe consume more energy on a per capita basis. This is no surprise, as modern economies require energy. Decreases in per capita consumption continue, owing to energy efficiency. Asia Pacific, South and Central America, and Africa consume significantly less energy on a per capita basis. This is changing, as their economies begin to grow. Approximately 78% of the global population (~ 6 billion people) live in Asia Pacific, South and Central America, and Africa today. Providing them modern energy is a major challenge.

Statement 8. A similar story emerges when looking at just the power sector, with the Asia Pacific, comprising 4.6 billion people (55% of global population and growing) dominating electricity generation, having grown over 700% in demand since 1985. The data are generation in Terawatt hours (Twh), not installed capacity, which masks generation capacity factors for different energy sources.

Statement 9. Asia represents 75% of the world's coal generation for electricity. Of the approximate 13,000 Twh of total electricity generated in Asia, 58% comes from coal. In other words, charging electric vehicles in Asia is done with 58% coal. Coal is used for many other things, in addition to electricity.

Statement 10. Coal consumption in Asia for power generation continues to increase, as does overall coal consumption in Asia. Although pledges have been made by China to go "carbon neutral" by 2060, they, and other countries in Asia, continue to build coal power plants at a rapid rate. These plants will operate for 60 to 80 years.

Statement 11. Natural gas (CH_4, mostly hydrogen) is increasing as a fuel for electricity generation in every geopolitical sector. The global natural gas/coal ratio in electricity generation has grown from 38% in 1965 to 62% in 2019, and continues to increase.

Statement 12. Solar and wind are the fastest-growing sources of electricity in terms of rate. However, in actual Twh of generation, solar and wind supplied only 8.0% of global electricity, and 3.3% of total global energy in 2019. After 15 years of growth, solar and wind represent only 24% of the growth in demand for electricity from 2005 to 2019.

Statement 13. Anthropogenic sources of CO_2 come from several sectors including, in relative order of amount, electricity generation, agriculture and land use, transportation, manufacturing, and heating and cooling. Global CO_2 emissions track Primary Energy consumption by region, with the U.S. and Europe decreasing, Asia growing tremendously (50% of global), and the rest of the world just getting started.

Statement 14. There has been much work done on strategies to reduce global CO_2 emissions starting in 2005 with the thoughtful "wedge" approach out of Princeton. To address climate change, an approach must address scale (billions of tons per year) and cost (trillions of dollars) and time frame (a decade or two). In electricity, the surface power density of energy options is very important. An objective look suggests that although solar and wind, and the batteries to make them reliable, have a role to play, they have power densities so low that a tremendous amount of non-renewable "stuff" to make the panels, turbines and batteries is required to capture and store the wind and the sun. This "stuff" would require an unprecedented scale of global mining and manufacturing, and later landfill disposal when the panels, turbines, and batteries wear out. Robbing from nature Peter to pay climate Paul. By contrast, nuclear with zero emissions or fuel switching from natural gas to coal both provide dispatchable electricity and address the challenge of scale, cost, and time frame. Hydro (largest source of renewable energy today) and geothermal are both dispatchable, and although very low power density, still have roles to play.

Energy source Median PD [W/m2] Natural gas 482.10 Nuclear power 240.81 Petroleum 194.61 Coal 135.10 Solar power 6.63 Geothermal 2.24 Wind power 1.84 Hydropower 0.14 Biomass 0.08

Statement 15. In terms of fuel switching, U.S. CO2 emissions from the power sector have decreased substantially. In fact, the U.S. met the proposed 2015 Clean Power Plan target emissions reductions for 2030 a decade early in 2020, without the Clean Power Plan. CO2 reduction was driven by affordable and abundant natural gas from hydraulically fractured ("fracked") shales replacing coal in power generation, and to a lesser degree, growth of wind and solar, efficiency gains, and exporting manufacturing overseas, mostly to Asia. Exporting manufacturing does not reduce emissions into the single global atmosphere.

Statement 16. Asia is developing its economy on coal just like the U.S. and Europe did. Asia consumes 11X more coal annually than the U.S. (122 Ej vs. 11 Ej). In terms of global CO2 emissions 15%, 29%, and 22% come from the U.S., China, and non-China Asia, respectively. The coal/gas ratio in the U.S. is 0.6X (decreasing); in China is 11.8X; and in non-China Asia is 3.2X (increasing). If Asia were to transition to a coal/gas ratio like the U.S., it would reduce Asian coal consumption by 2.8 Gt/yr. (billion tonnes/yr.), increase natural gas by 76 Tcf/yr., and result in a net reduction in CO2 emissions of 2.8 GT/yr. A substantial "wedge."

Statement 17. Carbon Capture, Utilization, and Storage (CCUS) represents a potential wedge. Work the past two decades indicates that, in the right setting, safe CCUS at scale is technically feasible. CCUS will require government incentives (e.g., Section 45Q tax credit) to make the economics work for those who own the pore space, those who develop the infrastructure, and those who pay others to honor their pledges. The ***Bureau of Economic Geology*** is a leader in CCUS. Under DOE Secretary Moniz, we pursued understanding of offshore CCUS, which is the most likely way to achieve scale, cost, and timeframe.

Statement 18. In terms of transportation, air, rail, ship, and vehicle, all present emissions challenges. For vehicles, internal combustion engines (ICE), electric vehicles (EV), and fuel cells (FC), all have advantages and disadvantages when it comes to reducing CO2 emissions without further damaging other parts of the environment. In terms of EVs, the mining and later landfill disposal required to power enough vehicles to impact CO2 reductions is unprecedented. To electrify half of today's vehicle fleet of 1.2 billion with the equivalent number of batteries in a single Tesla S (7100; see below) would require over 4 trillion new batteries every 15-20 years as the batteries wear out. Four trillion Tesla S batteries would build a U.S. football field-sized solid battery tower 25 miles into the stratosphere. Global EV sales increased 46% from 2019 to 2020. Much of the growth happened in China and Korea, where sales rose by 135% and 60% respectively. Depending on the source of electricity (i.e., not coal in Asia), EVs can reduce emissions. But, mining, manufacturing, and disposing batteries is not "green."

Statement 19. China now controls much of the world's mineral refining capacity and mining resources related to batteries and solar panels, which presents a national security risk with increased vehicle electrification. Mining practices in parts of the world violate human rights. To manufacture and deploy enough solar panels, wind turbines, and batteries to replace dispatchable coal, natural gas, and nuclear will require tremendous land use and mining of non-renewable lithium, cobalt, copper, other metals, rare earth elements, polysilicon, etc. It will also require landfill disposal of massive and toxic materials.

Statement 20. The levelized cost of electricity (LCOE) for solar and wind are now below coal, and in places natural gas. Unfortunately, LCOE is incomplete because it represents the cost of electricity at the generation source, not the actual cost to the consumer. To be reliable, intermittent solar and wind require almost 100 % redundant and expensive backup from natural gas plants or batteries, which makes them more expensive to the consumer. This is partly why people in California, the N.E. U.S., and Germany pay more for electricity. The higher cost is regressive and inequitable to low-income people.

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