

SOM Macro Strategies

State Of the Markets: Key Opportunities On The Path To Net-Zero GHG

Part 3: The Building Of A Nationwide Renewable Electric Grid

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Alan Brazil

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State Of the Markets: Key Opportunities On The Path To Net-Zero GHG

Part 3: The Building Of A Nationwide Renewable Electric Grid

- Part 1: Framing the magnitude of a net-zero GHG emissions policy for the world and the US
 - Example of transitioning to a 100% electric vehicles
 - Example of projected costs for the US of a 100% renewable energy grid
- Part 2: Three Observation From The Texas Blackout That Highlights These Opportunities
 - Observation 1: Renewable Energy Is Variable By Nature And Is Particularly Vulnerable To Extreme Events
 - Observation 2: Renewable Grids Need To Have Substantial Overcapacity Or Days Worth Of Storage To Replace Carbon
 - Observation 3: A Transmission Network Needs To Built To Link Major Wind And Solar Area To The Whole Country
- Part 3: Key opportunities along the path to Net-Zero
 - Government policy will incentives the building of a new nationwide renewable based electrical grid
 - The move will drive a conversion of fossil-based energy consumption to one based on renewable energy, mostly solar and wind
 - Total investment could be \$6-8 trillion, which is close to an annual investment rate of 1 to 2% of GDP for thirty years
 - Scale will dwarf the size of the existing electrical grid
 - The building of the nationwide renewable grid could be similar in dynamics as was the building of the transcontinental railway system in the 1860s
 - The private sector will build the new grid driven by government policy and incentives
 - New wind and solar farms capacity will need to be roughly 20 times their current capacity
 - Spur lines will be need to built to connect the wind and solar farm to the existing grid
 - Regional and nationwide high voltage DC transmission lines will also be built to reduce the impact a grid based on renewable but variable energy
 - Buy equities of companies that will be building the new grid

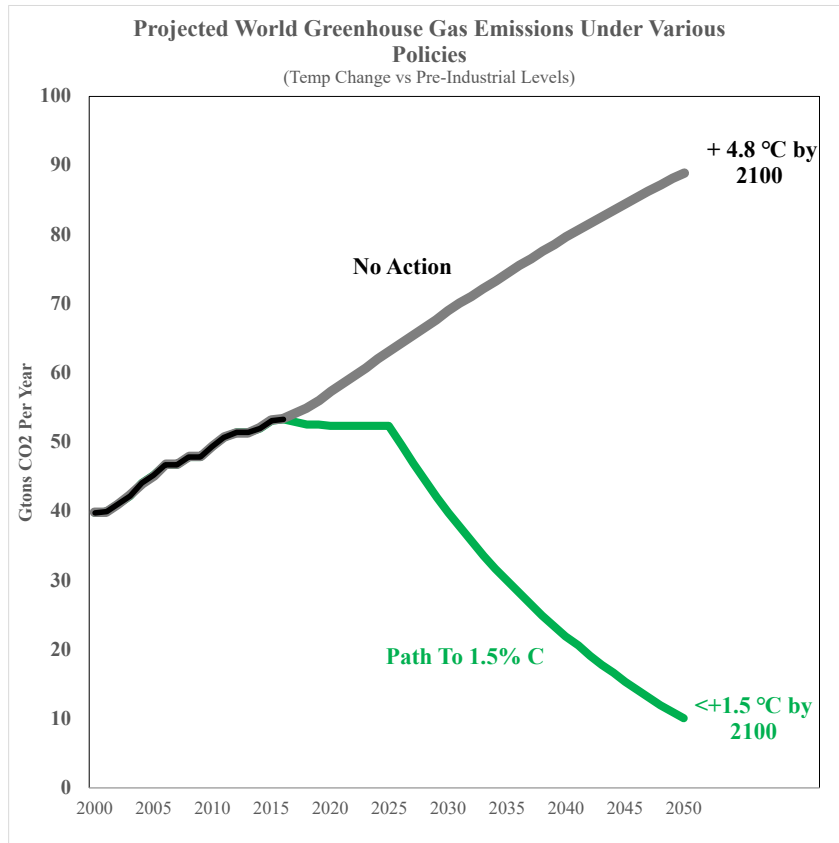
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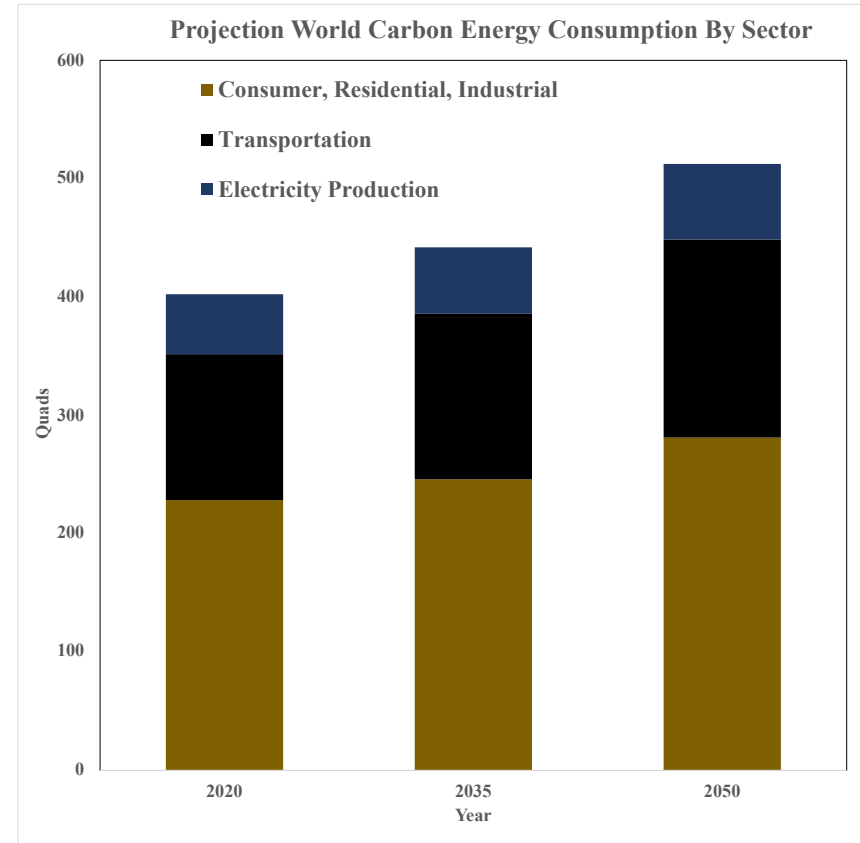
Step 2: Fundamental Economic Framework

Green House Emissions Will Continue To Grow Without A Path To Net-Zero

The Risk Of Global Warming



Transportation And The Non-Power Sector Are The Biggest Source



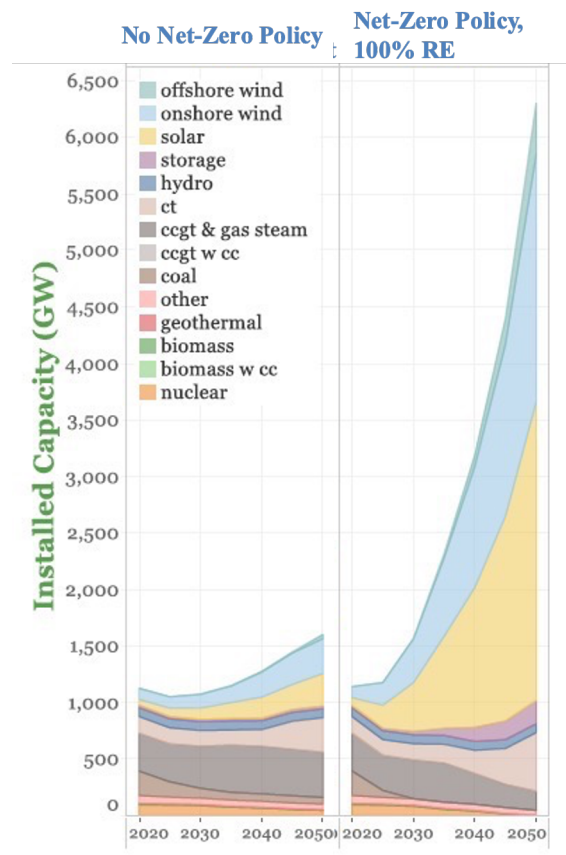
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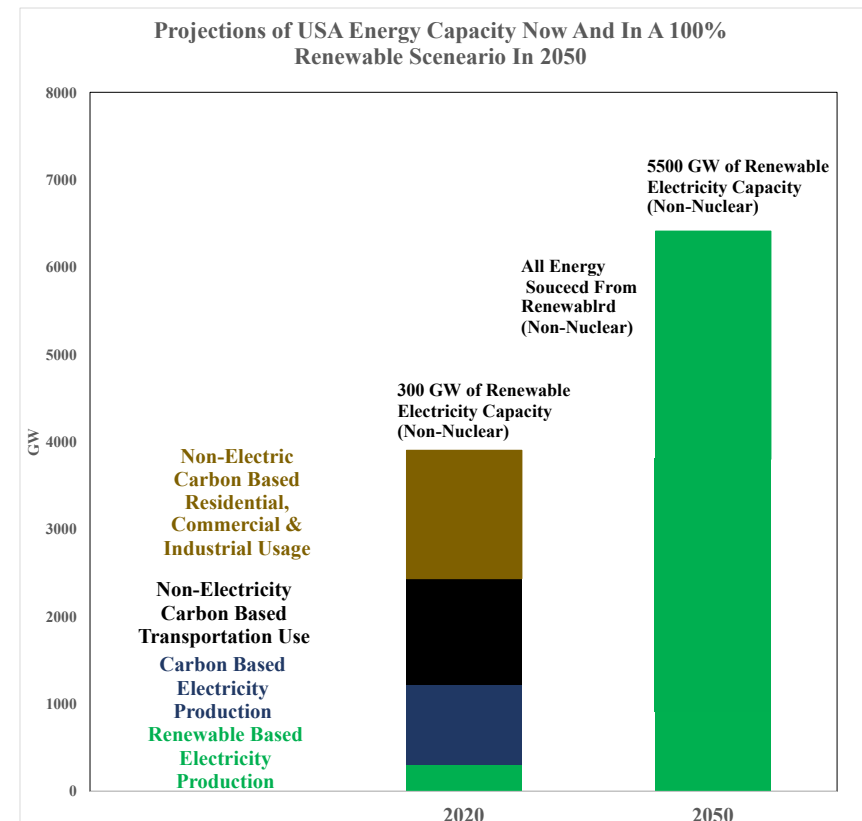
Step 2: Fundamental Economic Framework

Net-Zero Can Only Be Achieved By An Exponential Growth In Renewable Electricity Capacity¹

In The US, Renewable Capacity Needs To Grow By 20 Times



In The Zero-Net World All Energy Use Must Convert To Renewables



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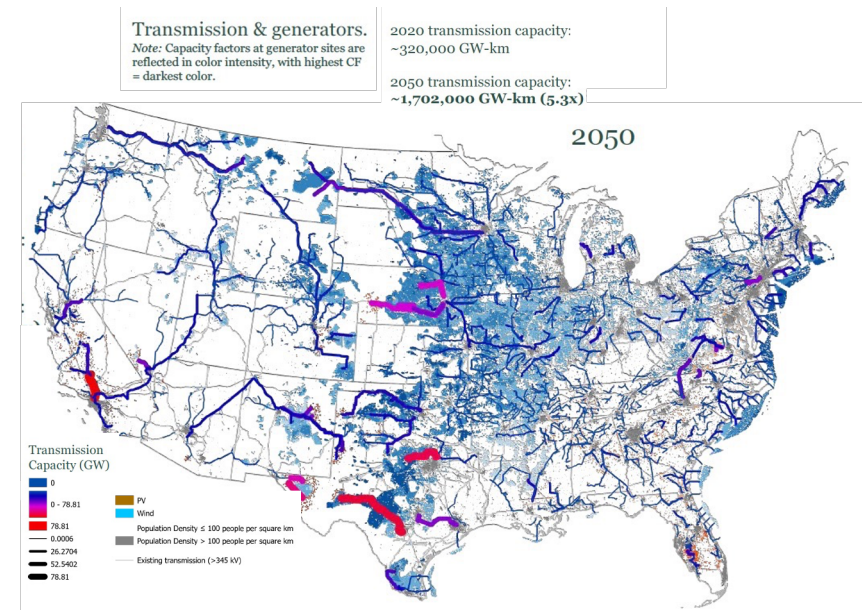
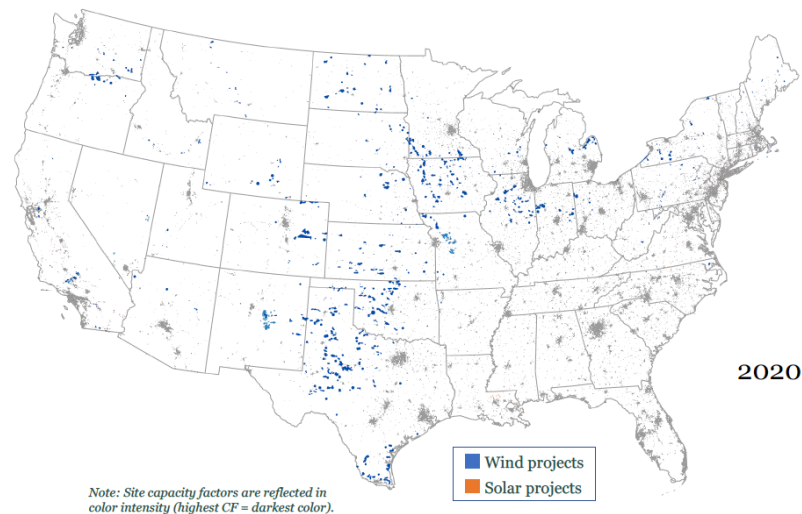
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Step 2: Fundamental Economic Framework

The New Renewable Grid: Wind And Solar Farms Connected With A New Transmission System

The 100% Renewable Grid Expands From This....

To This....



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Step 2: Fundamental Economic Framework

A Renewable Electrical Transmission Grid Will Look As Extensive As the Carbon Grid Does Now

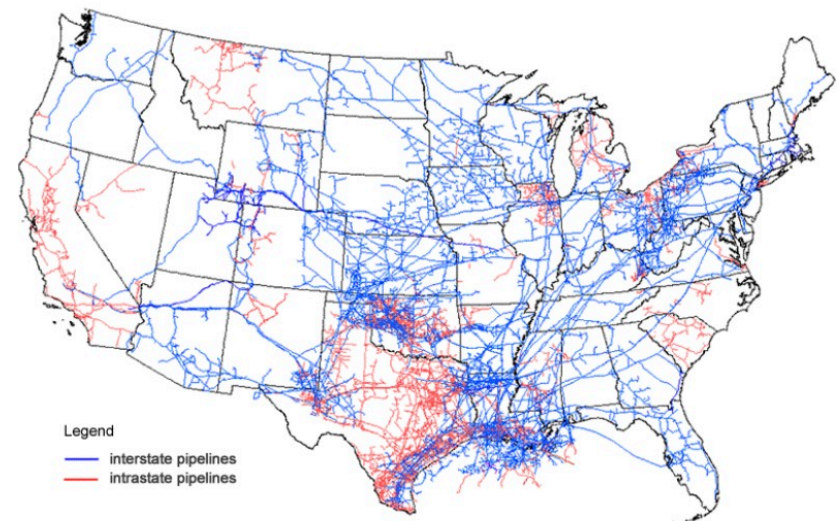
Coal Gets Shipped On Railroads to Utilities Through Out The US¹

Map Of US Freight Railroad Lines



Nat Gas Is Distributed To Utilities Country Wide Through Pipelines²

Map of U.S. interstate and intrastate natural gas pipelines



Source: U.S. Energy Information Administration, About U.S. Natural Gas Pipelines

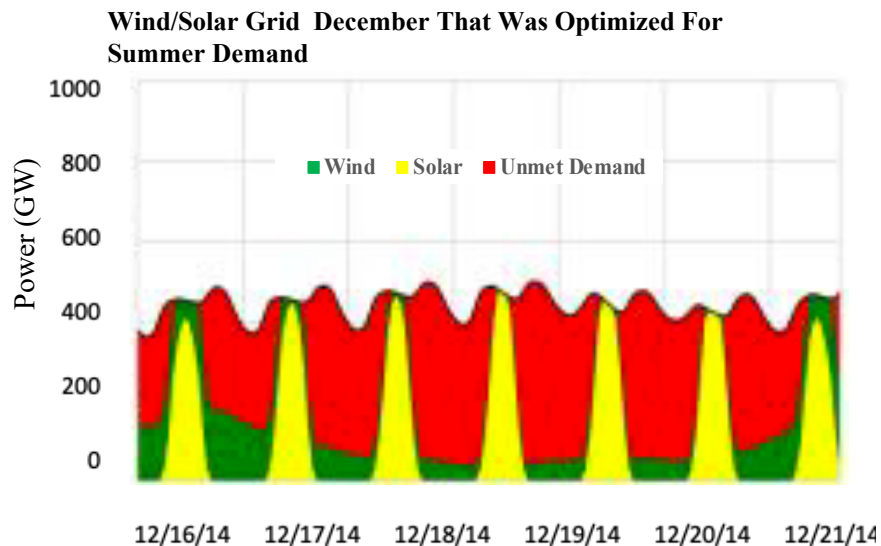
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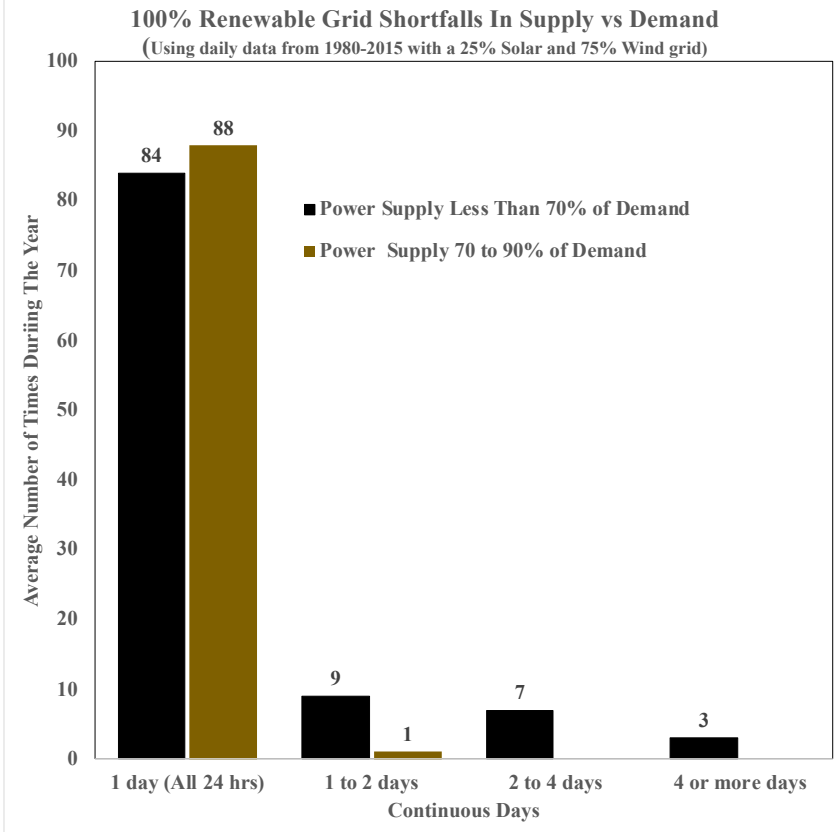
Step 2: Fundamental Economic Framework

New Spur Lines Do Not Overcome The Variable Nature Of Wind And Solar Energy¹

Not Enough Wind/Solar Energy To Supply Demand In Winter



A 100% Renewable Grid Could Face For Days Of Blackouts



1. Shaner, Matthew & Davis, Steven & Lewis, Nathan & Caldeira, Ken. (2018). Geophysical constraints on the reliability of solar and wind power in the United States. Energy & Environmental Science

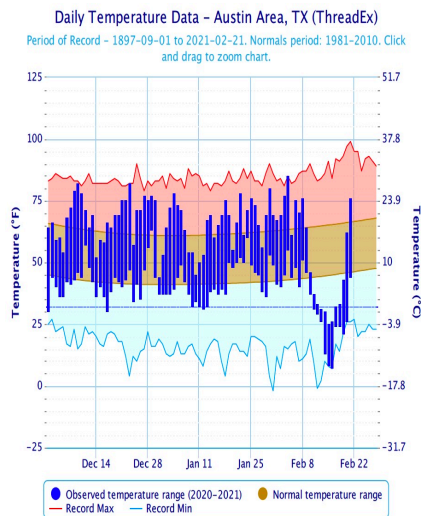
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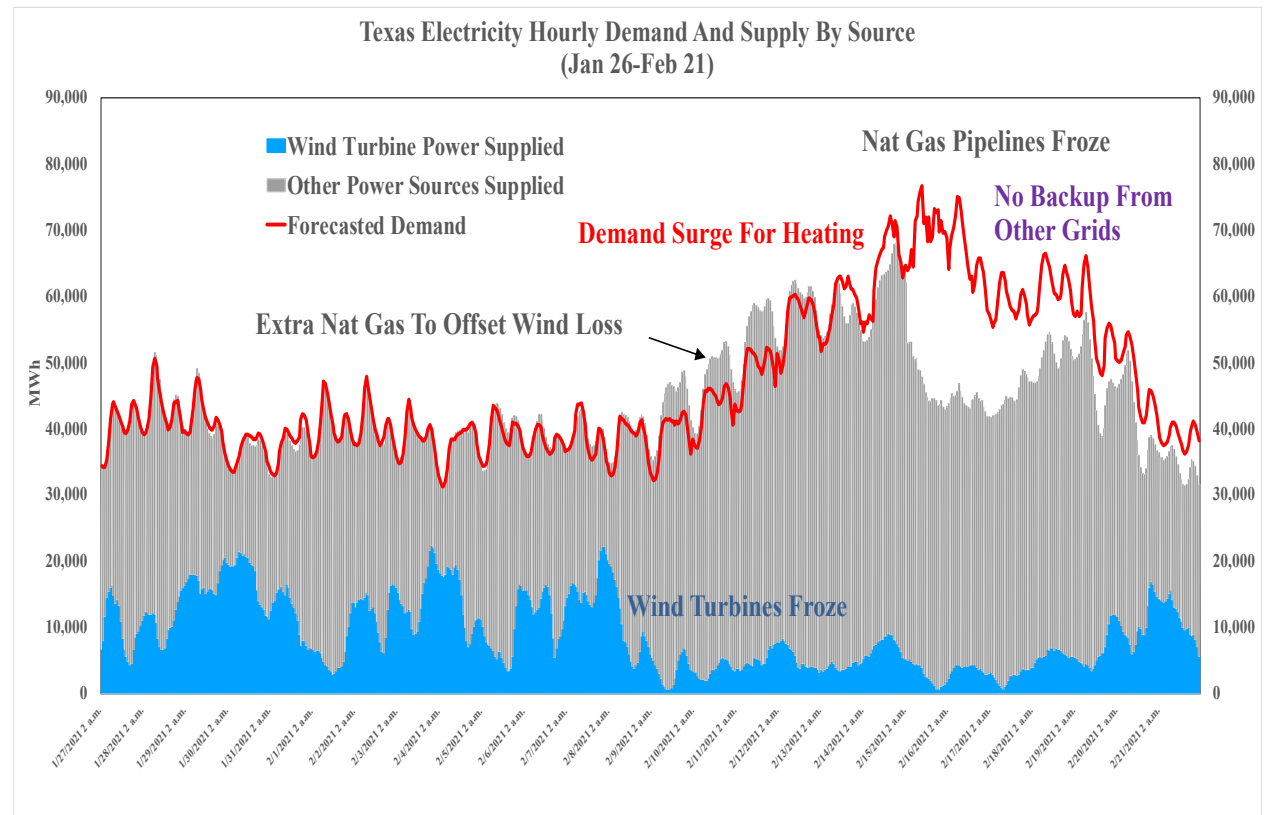
Step 2: Fundamental Economic Framework

Impact Of The Variability Of Renewable Energy Illuminated With Freeze Of The Texas Electrical Grid

Texas Temps Fell To Record Lows¹



Loss Of Wind Power Started The Event Then The Gas Pipelines Froze²



1. National Weather Service
2. EIA

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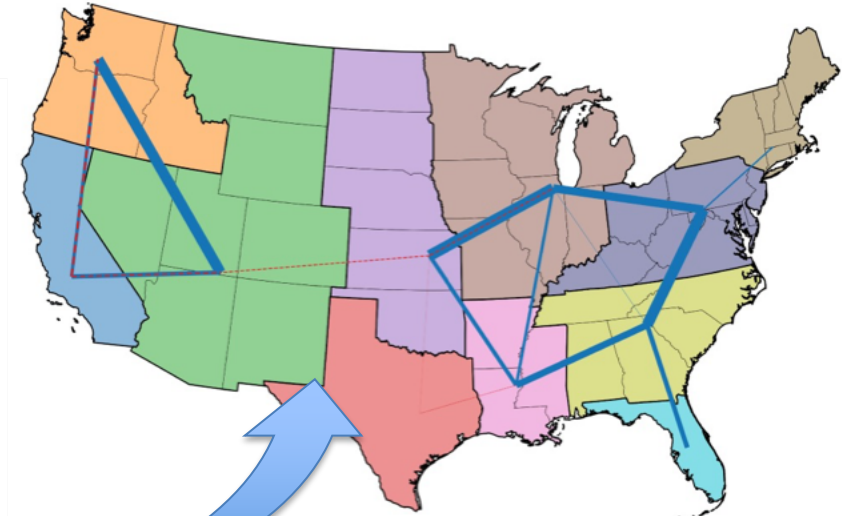
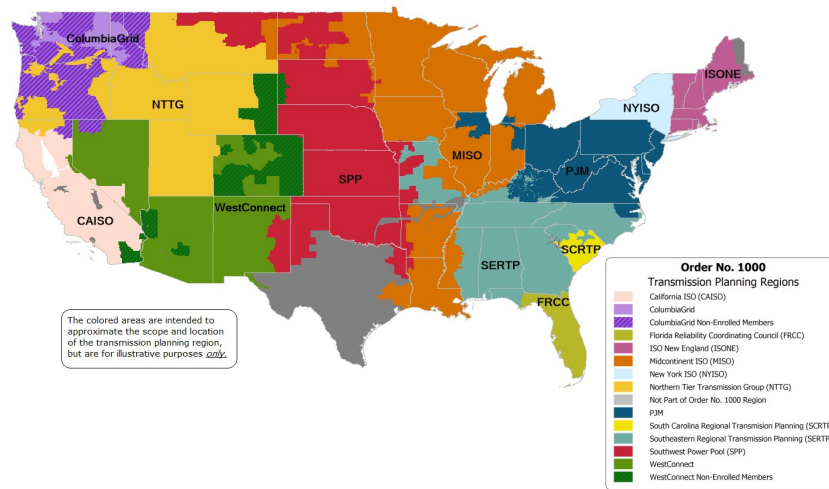
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Step 2: Fundamental Economic Framework

Problem In Texas Also Illuminated The Lack Of A Nationwide Connected Transmission Grid

US Grid Is Broken Up Into Regional Grids¹

There Is Limited High Voltage Connection Across Regions²



Texas Was Cut Off From Other Regional Grids

1. FERC
2. Patrick R. Brown and Audun Botterud, "The Value of Inter-Regional Coordination and Transmission in Decarbonizing the US Electricity System", Joule, Volume 6, January 2021

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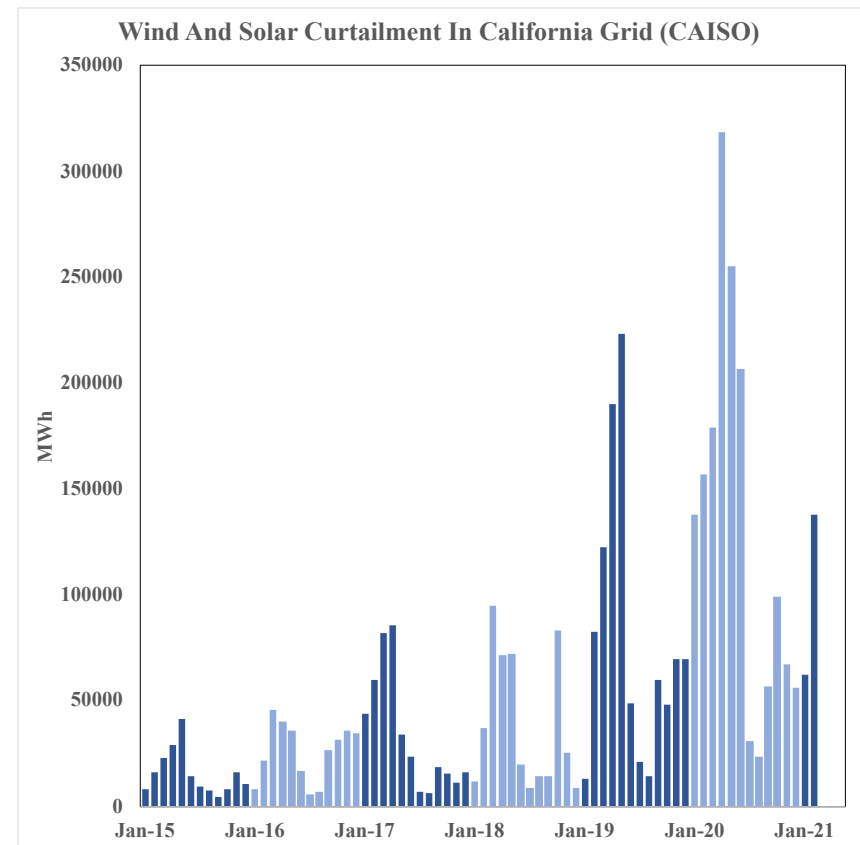
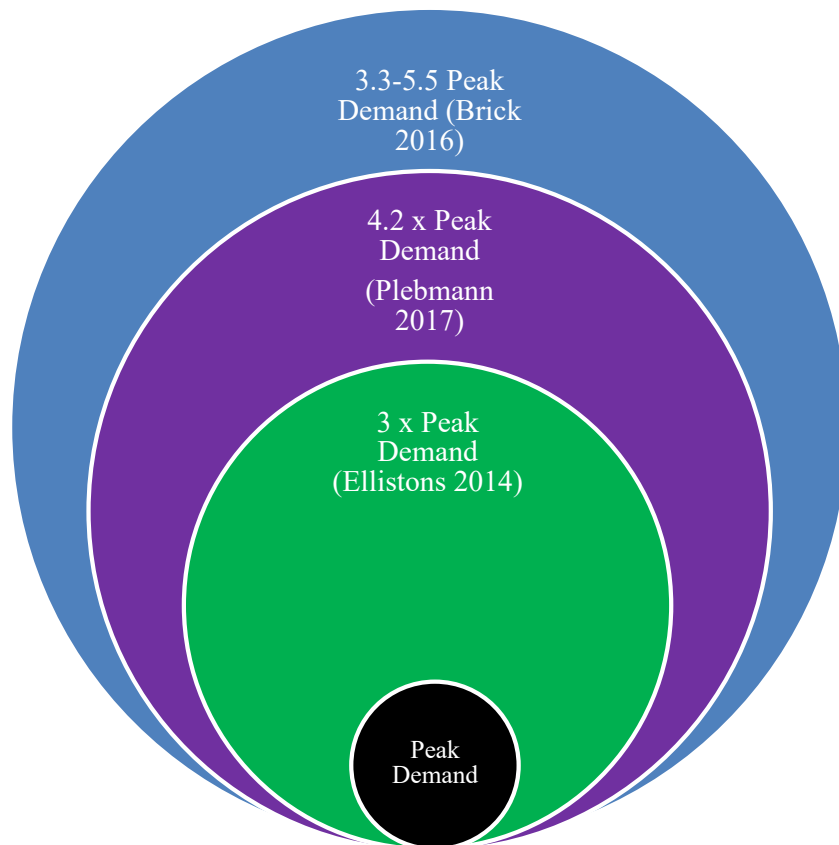
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Step 2: Fundamental Economic Framework

The Renewable Grid Will Overcapacity To Deal With Variable But That Increases Electric Costs

Capacity Will Need To Be 3+ Times Peak For 100% Reliability...¹

That Means Higher Electricity Costs, Reflected In Curtailments²



1. Jenkins, J.D., & Thernstrom, S., "Deep decarbonization of the electric power sector: Insights from recent literature. Energy Innovation Reform Project (EIRP), 2017
2. CASIO

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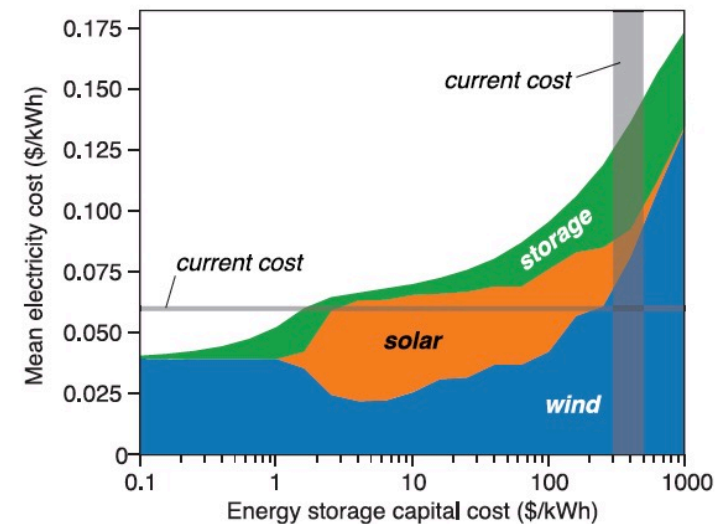
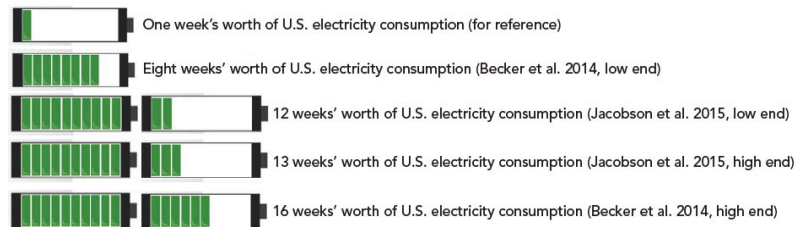
Step 2: Fundamental Economic Framework

Alternatively, Battery Storage Could Be Used To Reduce Variability But That Is Expensive As Well¹

A 100% Renewable Grid Needs Weeks Of Battery Storage....

That Also Means Substantially Higher Electricity Costs

Figure 3. Energy Storage Capacity Required in 100% Renewable Electricity Scenarios



1. Jenkins, J.D., & Thernstrom, S., "Deep decarbonization of the electric power sector: Insights from recent literature. Energy Innovation Reform Project (EIRP), 2017

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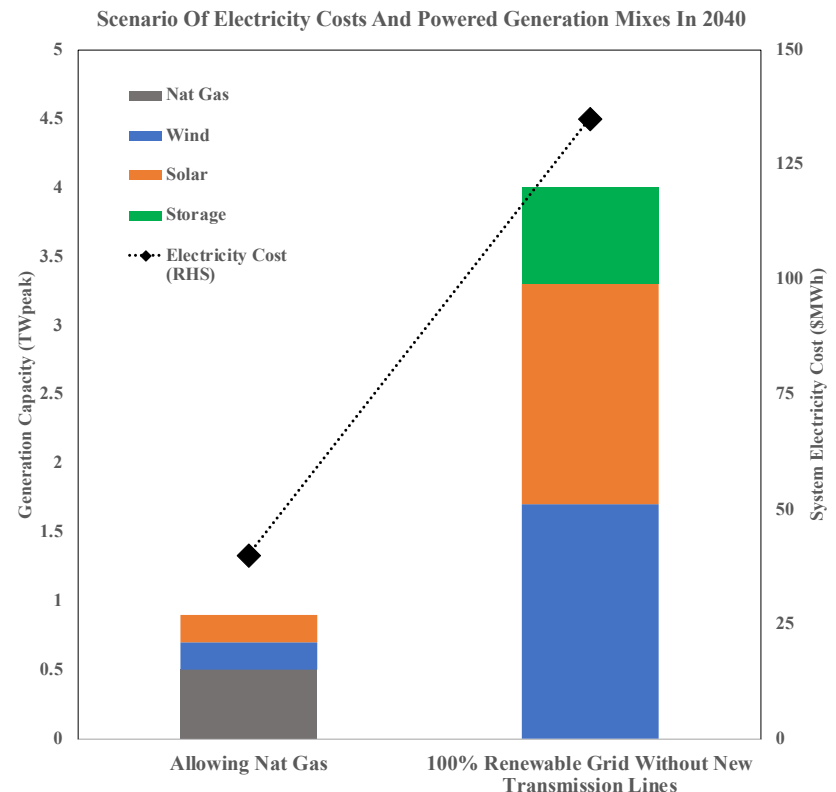
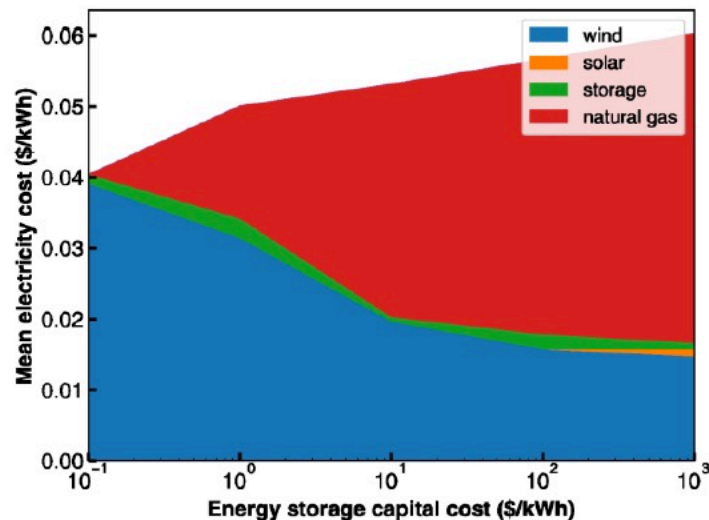
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Step 2: Fundamental Economic Framework

A Disconnected Renewable Grid Means Higher Electricity Costs Or More Reliance On Nat Gas

Nat Gas Dominates Solar And Battery In An Unconstrained Grid^{1,2}

Costs Are Higher Because of Need For Battery And Over Capacity³



1. Jenkins, J.D., & Thernstrom, S., "Deep decarbonization of the electric power sector: Insights from recent literature. Energy Innovation Reform Project (EIRP), 2017

2. This cost minimizing combination of electricity production using nat gas, solar, wind and batteries with no constraints on percentage of renewables

3. Patrick R. Brown and Audun Botterud, "The Value of Inter-Regional Coordination and Transmission in Decarbonizing the US Electricity System", Joule, Volume 6, January 2021

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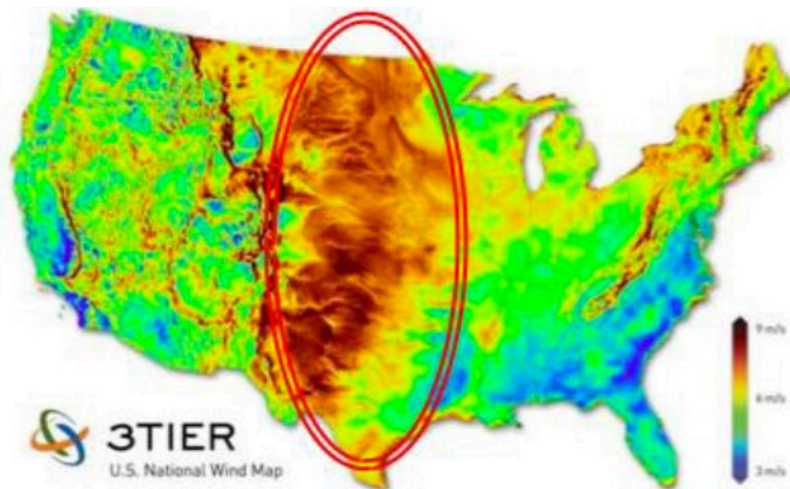
Step 2: Fundamental Economic Framework

A Better Option Is To Share Renewable Capacity Across Regions But That Is Not Possible

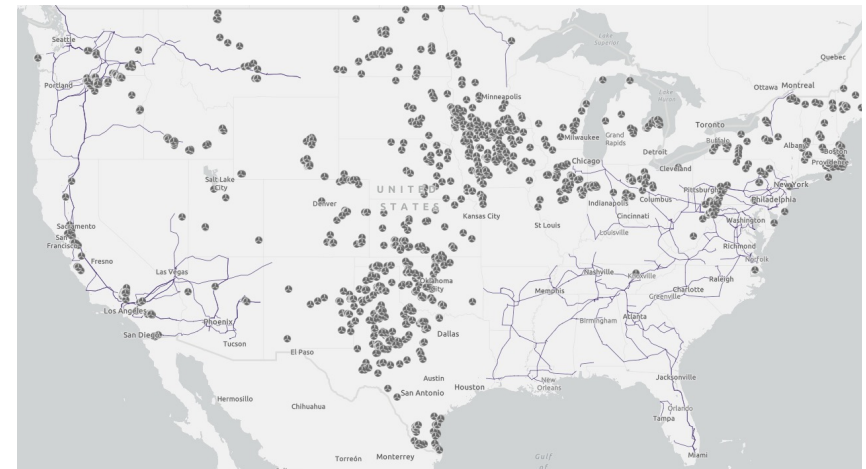
Wind Resources Are Highest In the Midwest And...¹

That Is Where The Bulk Of New Wind Farms Are Being Built²

Highest Potential Wind Energy



Current Locations of Wind Farms



1. A Silverstein, Transmission 101, presentation at the NCEP Transmission Technologies Workshop, April 2011

2. EIA

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Step 2: Fundamental Economic Framework

However, There Is No High-Capacity Electrical Transmission Lines To Carry That Energy To The Coasts

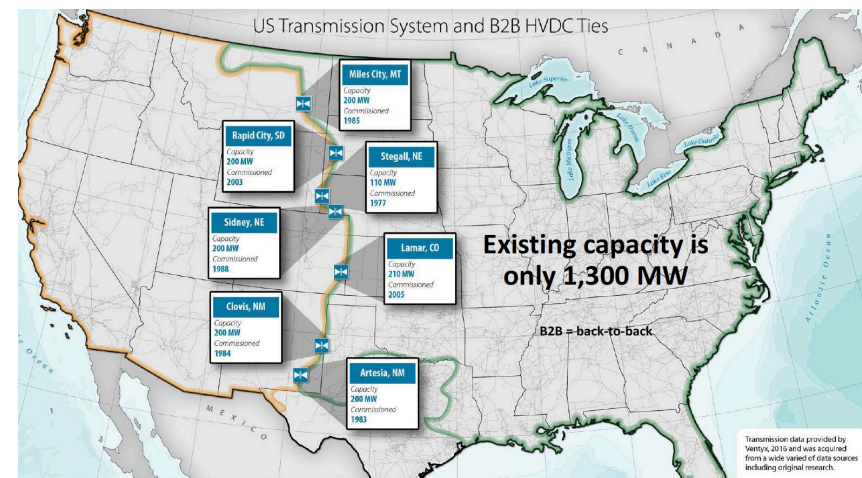
No High Capacity Lines Exist In The Midwest¹

The Interconnection Grid Is Of Very Low Capacity And Old²

**47% of Nation's Generation
Interconnection Queue**



Existing Transmission 500 kV and above shown.



1. A Silverstein, Transmission 101, presentation at the NCEP Transmission Technologies Workshop, April 2011
2. Brinkman, Novacheck, Bloom and McCalley, "Interconnections Seam Study", NREL, October 2020

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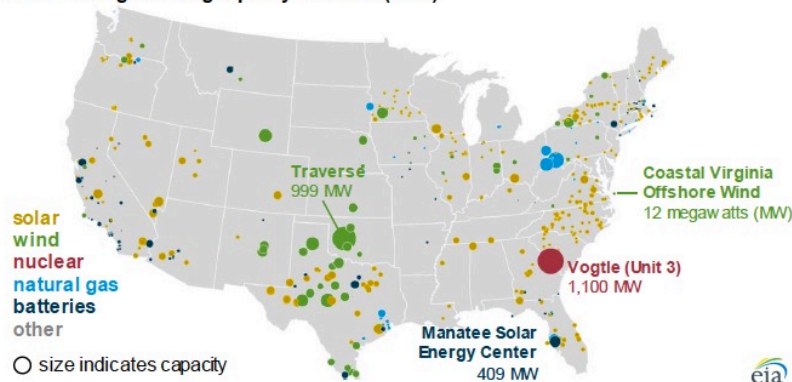
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Step 3: Identify Potential Catalysts

Biden's Infrastructure Plan Will Accelerate The Building Of The New Renewable Electric Grid

Renewables Dominate New Capacity¹

U.S. electric generating capacity additions (2021)



Biden's Infrastructure Plan Would Ramp That Up Substantially

Renewable energy infrastructure and support--\$400 bil

- Electrification of transportation (\$170 bil)
 - Tax incentive to private sector building of 500,000 charging stations
 - Point of sale incentives for purchase of EVs, elimination of hard cap for incentives based on sales
- Electricity grid modernization (\$100 bil)
 - Investment tax credit for building high voltage power lines
 - Extension of investment (ITC) and production tax credits (PTC) for renewable energy plants for 10 years
 - Adding targeted ITC for incentivizing the building 20 GW of high transmission lines

Traditional infrastructure--\$660 bil

- Roads, rail, transit, clean water, airports, broadband

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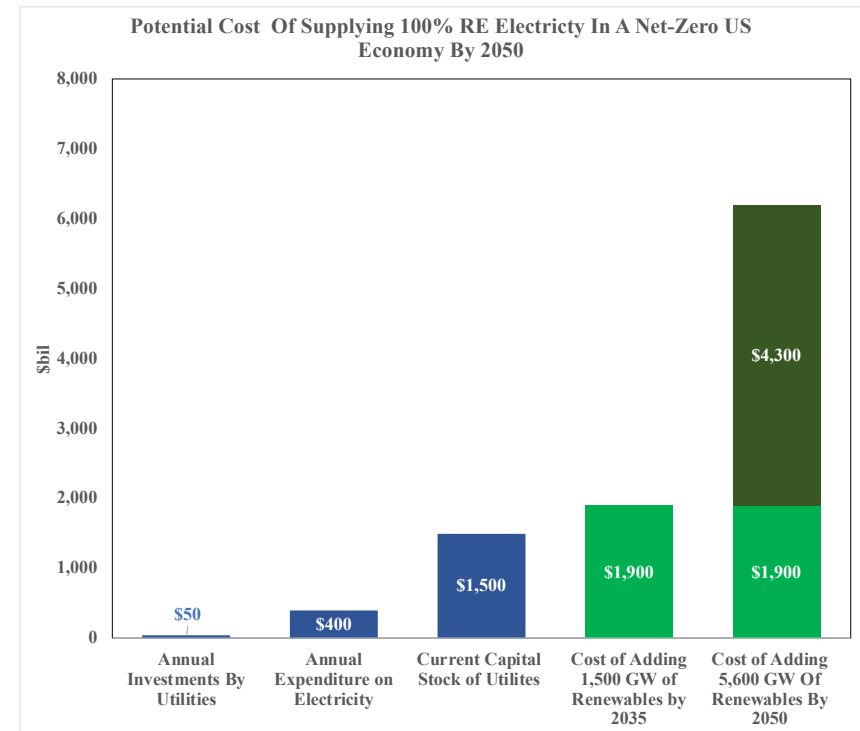
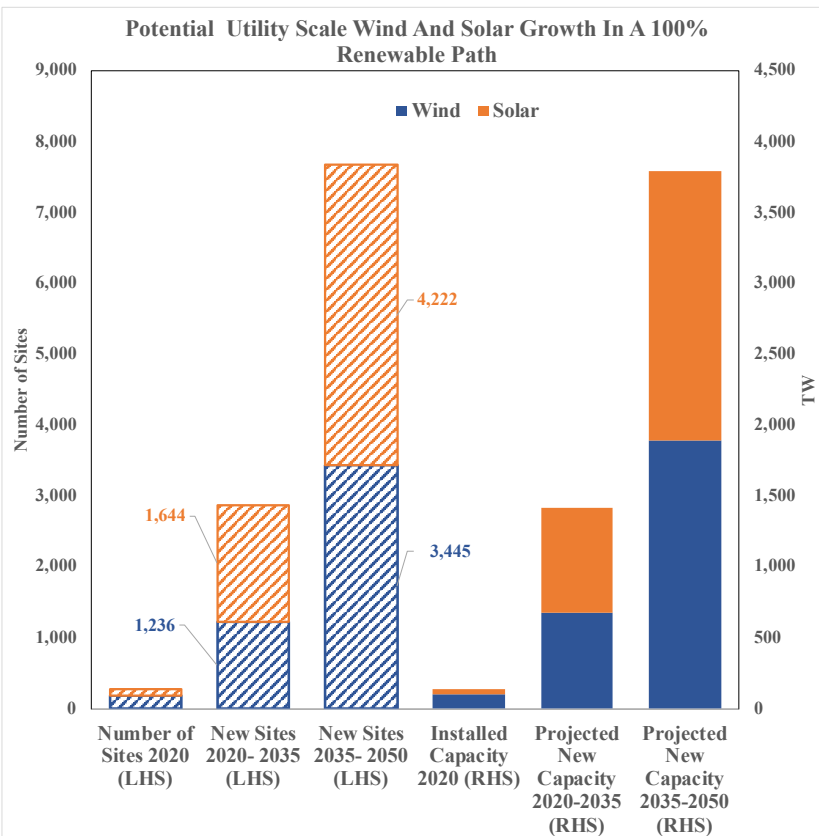
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Step 3: Identify Potential Catalysts

The Building Of The Utility Scale Wind And Solar Farms As Part Of The New 100% Renewable Grid

The Growth In Number And Footprint Will Be Exponential¹

Investment Will Be 3 to 4 Times The Value Of The Current Grid^{1,2}



1. E. Larson, C. Greig, J. Jenkins, E. Mayfield, A. Pascala, C. Zhang, J. Drossman, R. Williams, S. Pacala, R. Socolow, EJ Baik, R. Birdsey, R. Duke, R. Jones, B. Haley, E. Leslie, K. Paustian, and A. Swan, Net-Zero America: Potential Pathways, Infrastructure, and Impacts, interim report, Princeton University, Princeton, NJ, December 15, 2020.

2. BEA

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Step 3: Identify Potential Catalysts

The First Plan For A Nationwide Renewable Electric Grid Based On Hydroelectric

Proposed In 1923



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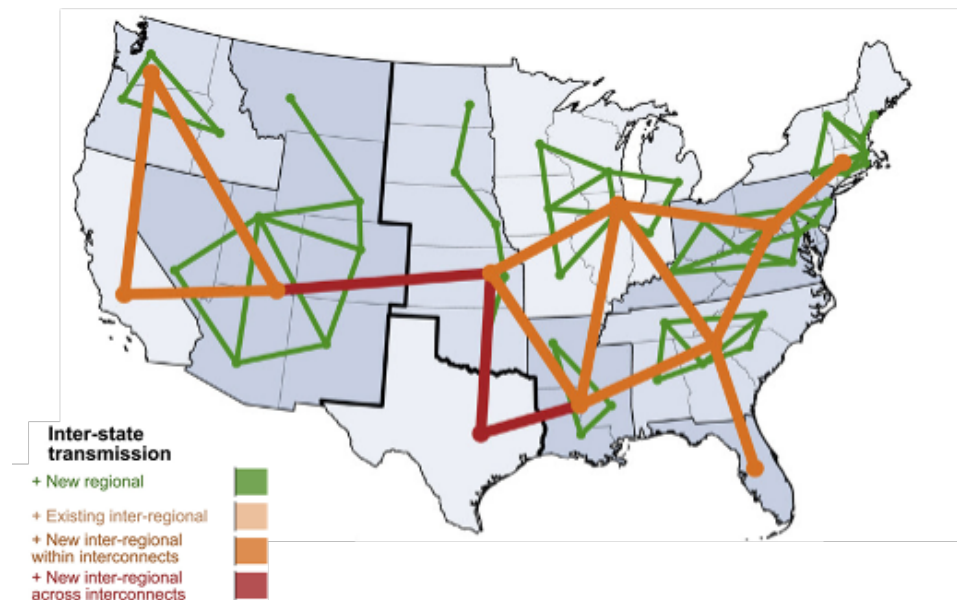
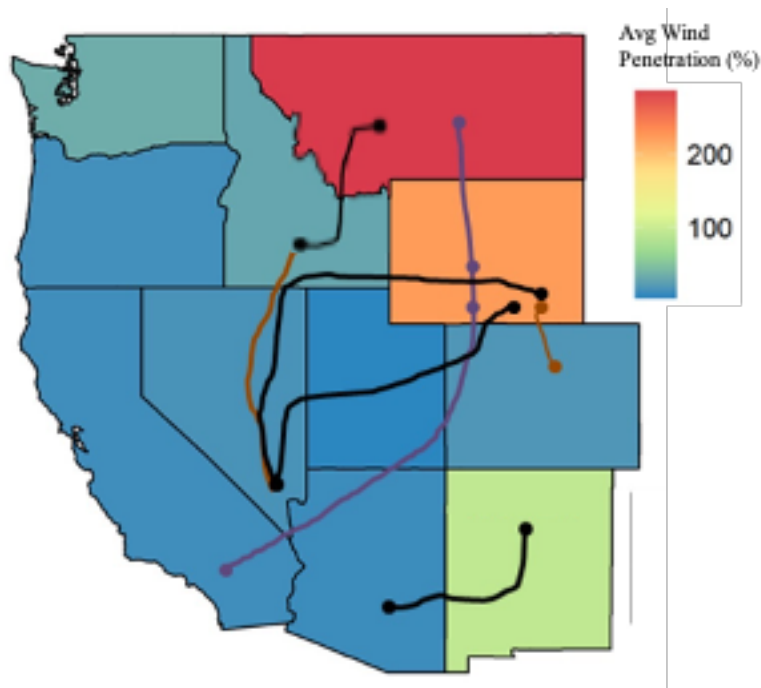
Step 3: Identify Potential Catalysts

The US Builds A Nationwide Renewable Electrical Transmission Grid Connecting Regions

The Grid Will Connect The Wind Regions To The Coasts...¹

And All Renewables Across The Country With High Voltage Lines²

5000 Miles of New Transmission And 15MM MW



¹

² Patrick R. Brown and Audun Botterud, "The Value of Inter-Regional Coordination and Transmission in Decarbonizing the US Electricity System", *Joule*, Volume 6, January 2021

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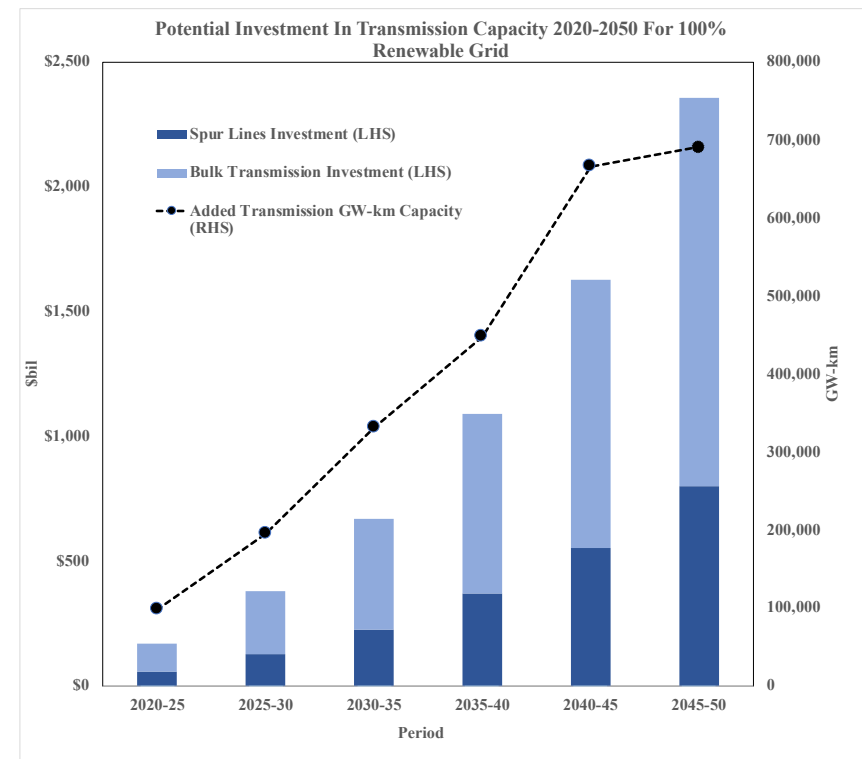
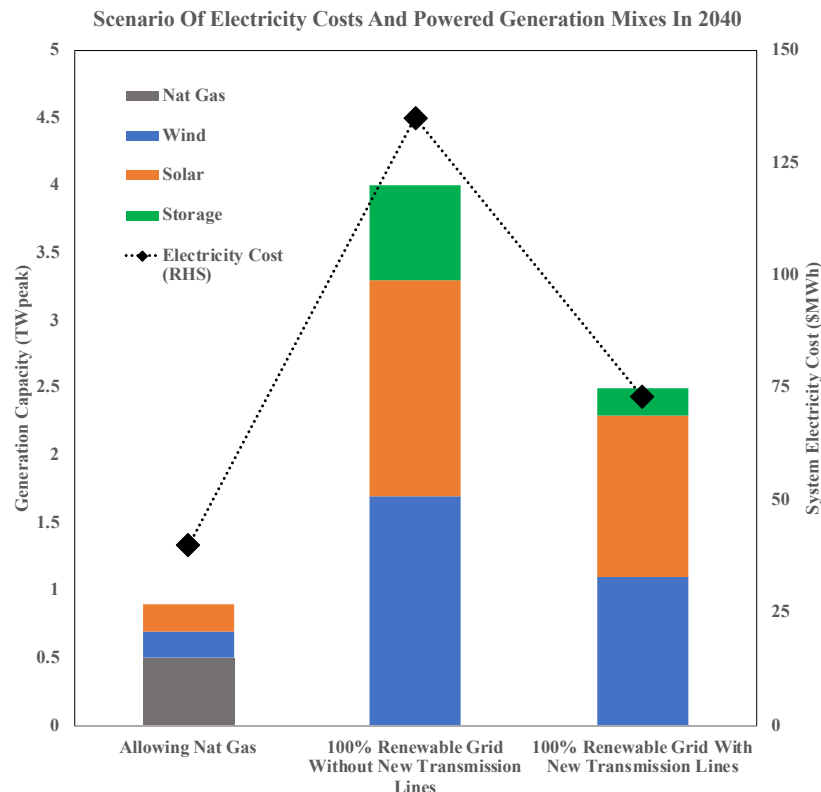
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Step 3: Identify Potential Catalysts

A Nationwide Transmission Grid Reduces The Problem of Overcapacity And The Need For Batteries

Linking Regions Reduces The Cost of Electricity...

Even Though It Means Trillions Of Investment



1. Patrick R. Brown and Audun Botterud, "The Value of Inter-Regional Coordination and Transmission in Decarbonizing the US Electricity System", Joule, Volume 6, January 2021

2. E. Larson, C. Greig, J. Jenkins, E. Mayfield, A. Pascale, C. Zhang, J. Drossman, R. Williams, S. Pacala, R. Socolow, EJ Baik, R. Birdsey, R. Duke, R. Jones, B. Haley, E. Leslie, K. Paustian, and A. Swan, Net-Zero America: Potential Pathways, Infrastructure, and Impacts, interim report, Princeton University, Princeton, NJ, December 15, 2020.

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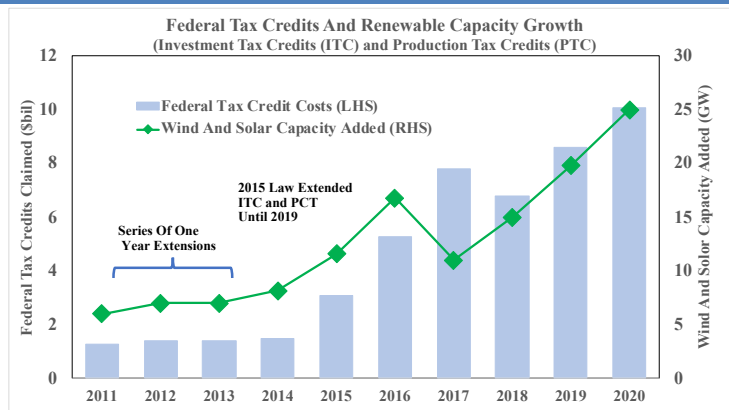
Step 4: Identify Asymmetric Trades

Trade 1: Buy Equities Of The Builders Of The New Renewable Grid--Old Tech Becomes New Tech

Trade Thesis

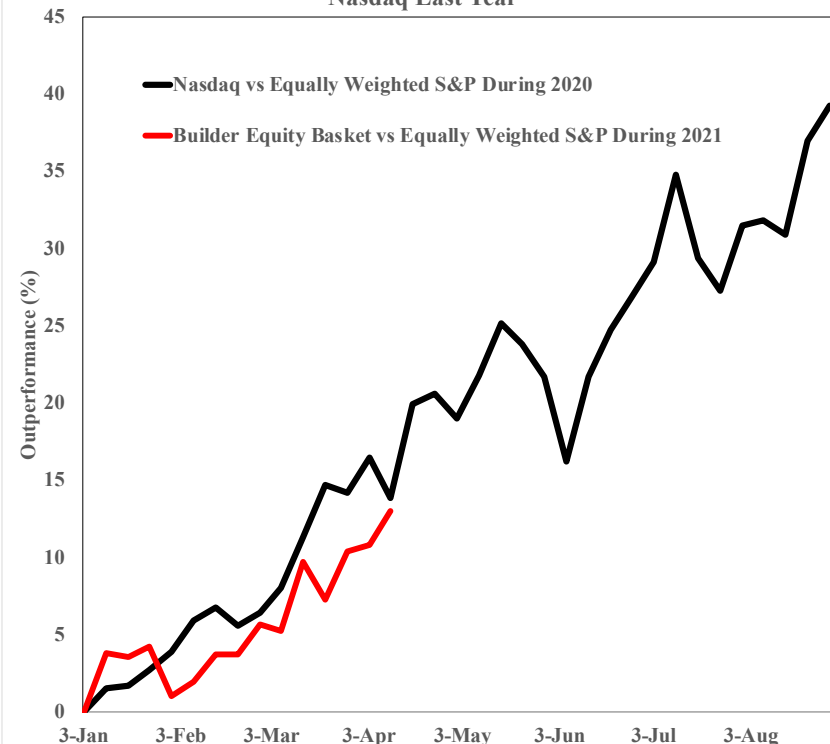
- Government policy ramps up the development of renewable energy
 - Utility scale wind and solar farms will experience exponential growth
 - Spur transmission lines linking the farms to the existing grid will see a similar level of growth
 - High voltage transmission lines will be built that will create a link renewable resources across the country
 - Investment will represent 1 to 2% of GDP for 30 years
- Private sector will build that new renewable grid leveraging government tax and other incentives
- The nonrenewable infrastructure federal plan will help the same companies that are also building the renewable grid

Private Sector Investment Will Be Multiples of Renewable Tax Breaks¹



Still Substantial Upside²

Builder Equites Performances This Year And Performance Of Nasdaq Last Year



1. CBO
2. Bloomberg

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