The Macroeconomic Benefits of the EV Transition

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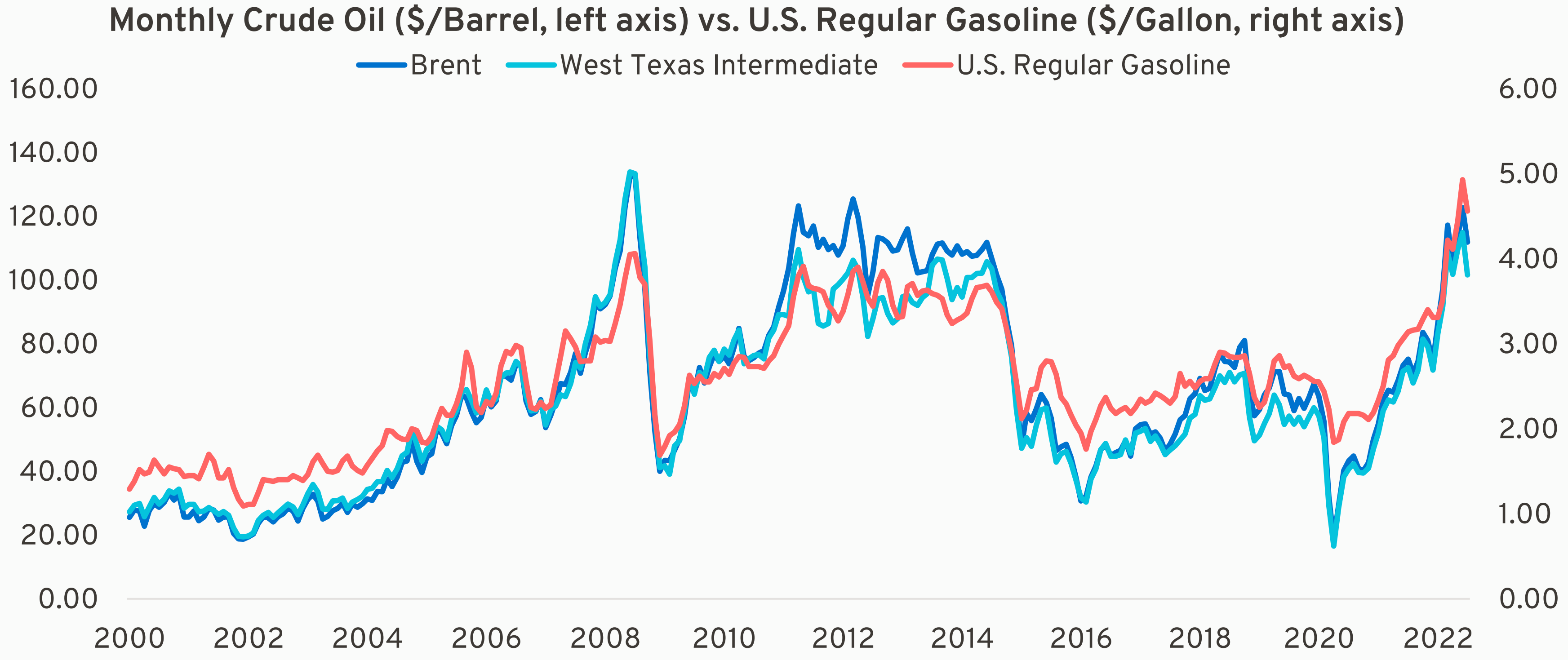
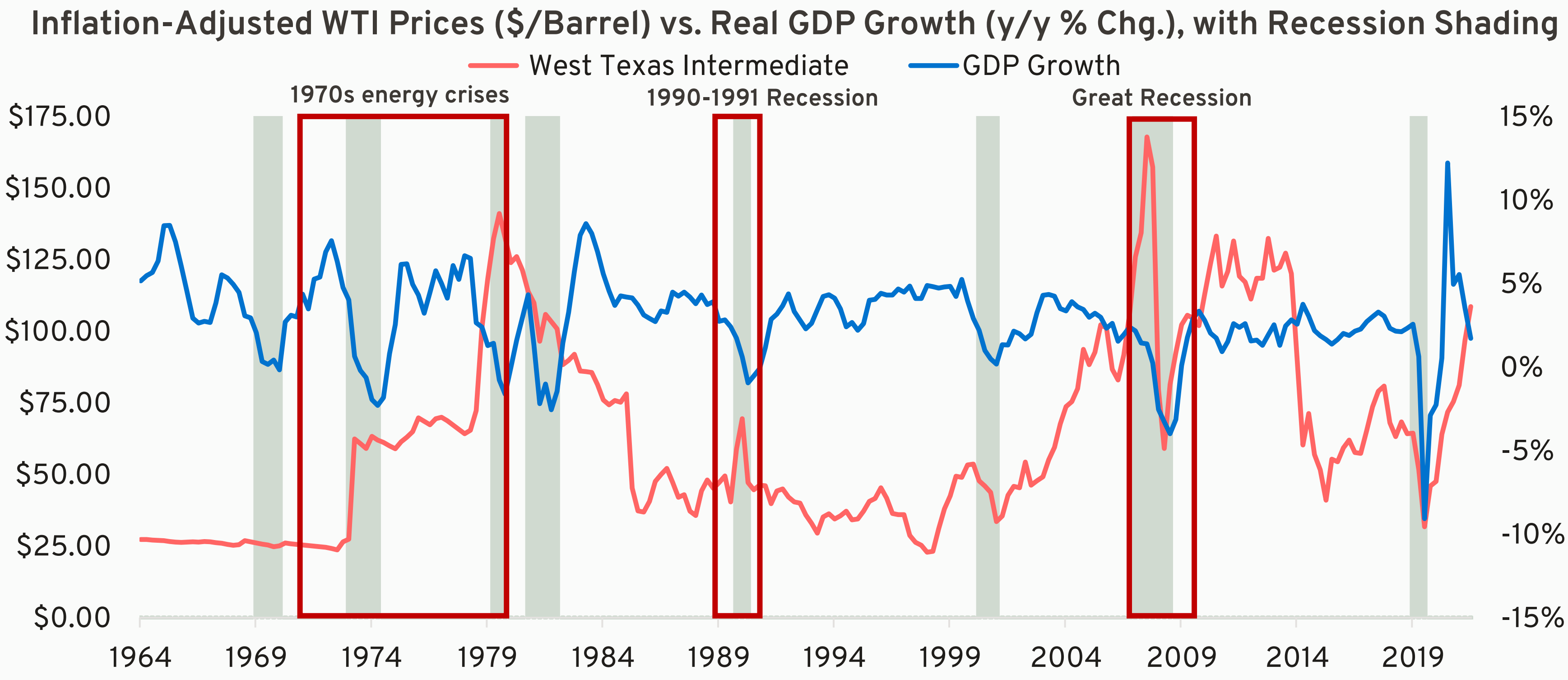
Global oil market volatility drives volatile gas prices

U.S. gasoline prices are closely tied to international oil prices



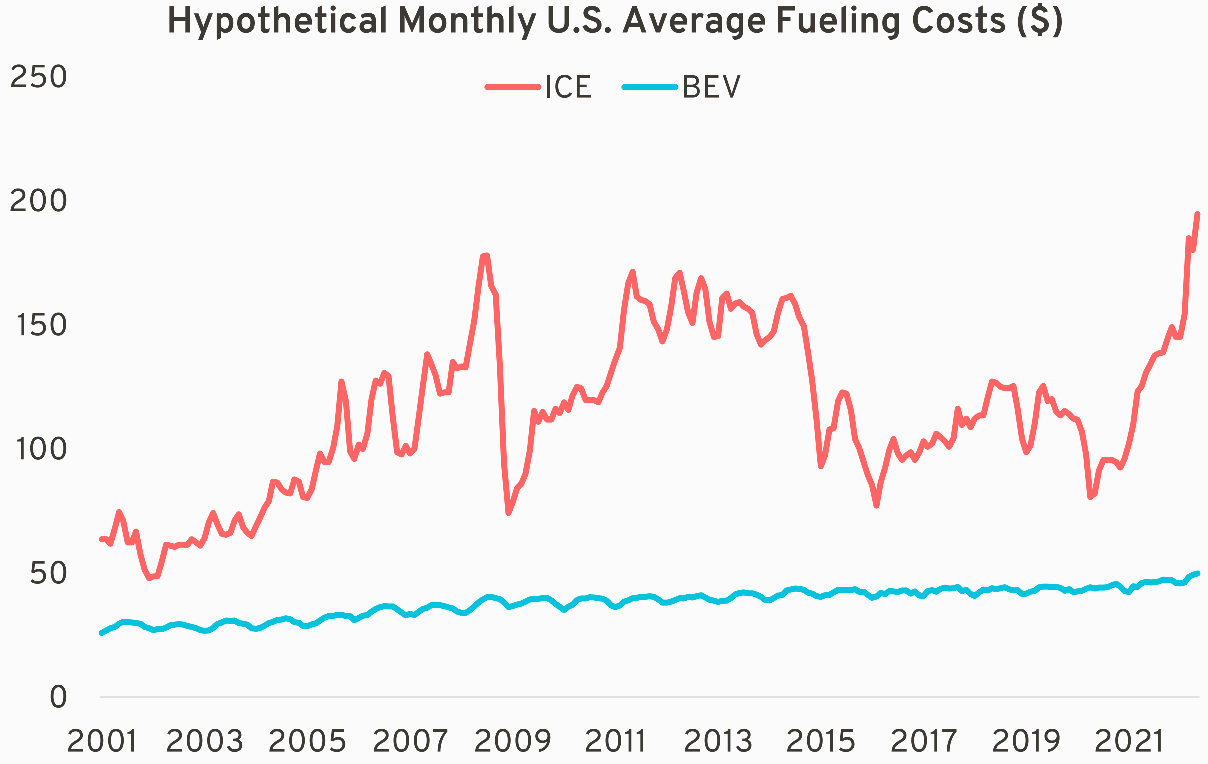
Sources: EIA, Haver Analytics

Large run ups in oil price preceded several U.S. recessions



Sources: EIA/Chicago Mercantile Exchange, Bureau of Economic Analysis, Bureau of Labor Statistics, National Bureau of Economic Research, Haver Analytics

U.S. EV owners are insulated from oil price volatility
Based on historical data, BEV fueling costs are lower and less volatile

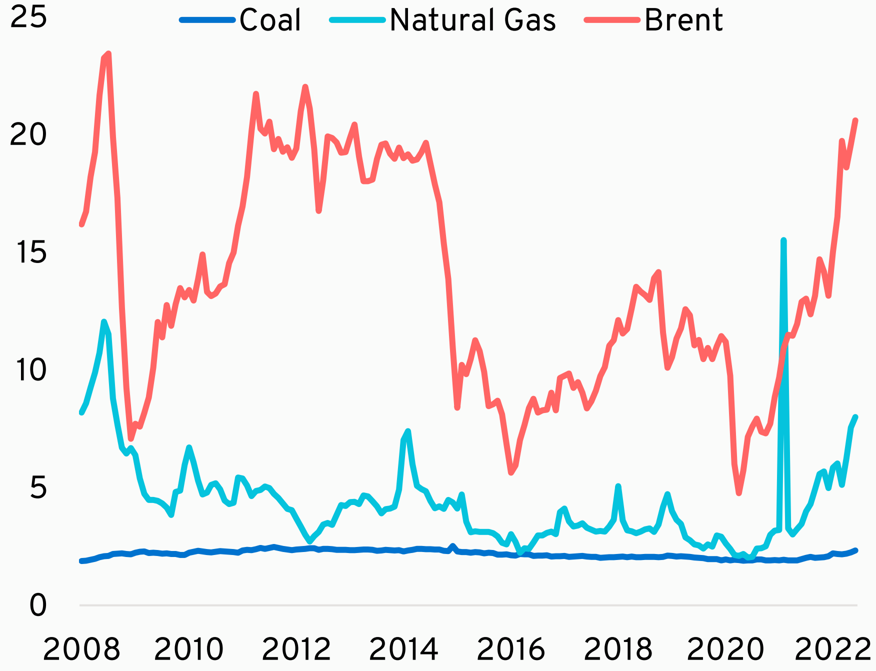


Fueling costs calculated assuming:

- 1,035 miles/month based on annual miles per vehicle of 12,416 according to Highway Statistics 2000; fhwa.dot.gov
- U.S. monthly average residential price of electricity per kWh. Residential electricity prices vary by state. *Source: EIA, Haver Analytics*
- U.S. monthly average regular gasoline price. *Source: EIA, Haver Analytics*
- Median efficiency of 2021 MY electric models is 104 mpge (or 3.1 mi/kWh). *Source: fueleconomy.gov.*
- Median fuel economy for 2021 MY is 23.6 miles per gallon. *Source: epa.gov.*

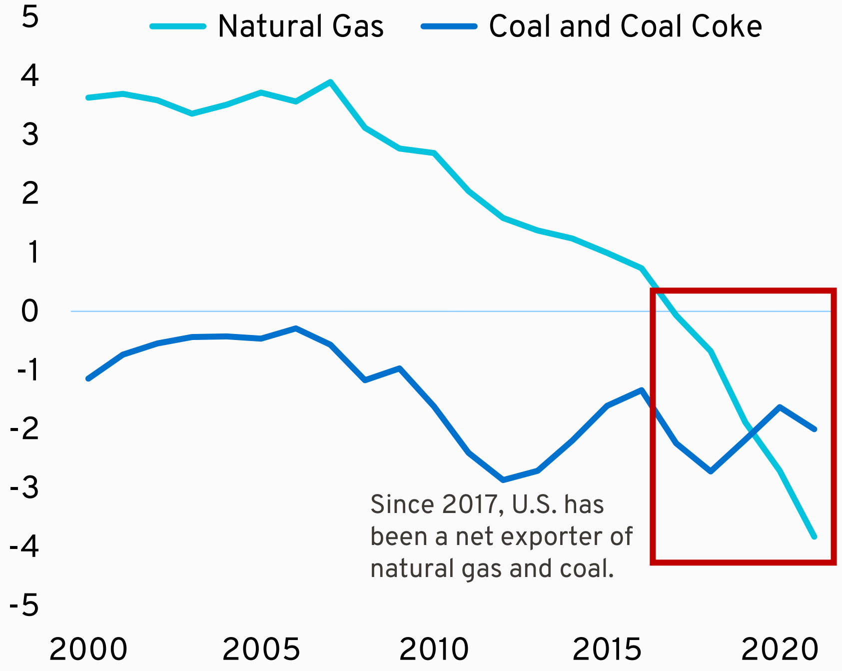
U.S. electricity grid is ~60% powered by coal and natural gas
whose prices are less volatile than oil and in which the U.S. is self-sufficient

Brent Prices vs. U.S. Cost of Fossil Fuels for Electricity Generation ($/M Btu)



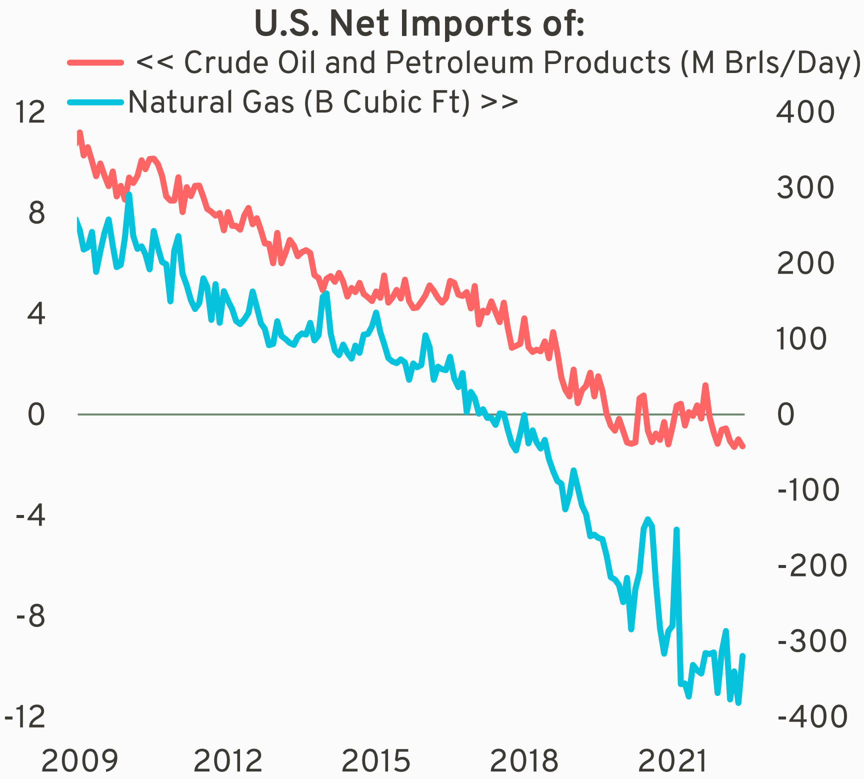
Sources: EIA, Haver Analytics. Assume 1 barrel of crude oil = 5,691,000 Btu; EIA.

Annual U.S. Natural Gas and Coal Net Imports (Quadrillion Btu)

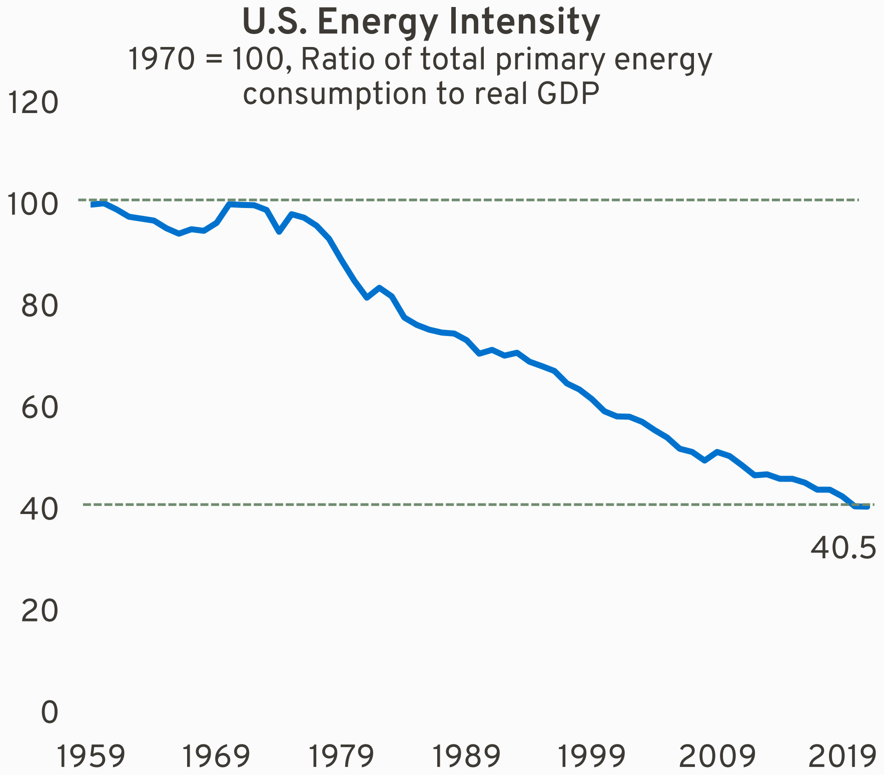


Sources: EIA, Haver Analytics

U.S. vulnerability to oil price shocks has fallen greatly due to increased U.S. production and greater energy efficiency



Sources: EIA, Haver Analytics



Sources: Bureau of Economic Analysis, Haver Analytics

Gasoline and diesel are 22-23% of current U.S. energy consumption and two-thirds of petroleum use

U.S. Share of Energy Consumption by Source

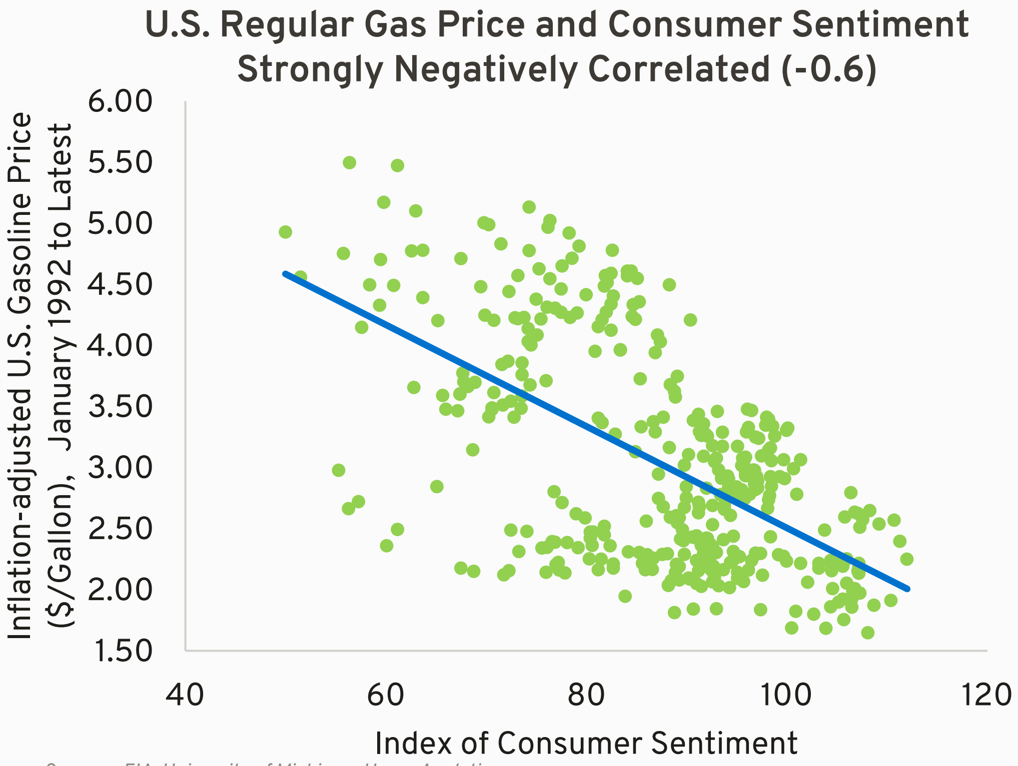
	2019	2020	2021
Petroleum	37	35	36
Motor Gasoline and Diesel[1]	23	22	23
Other Petroleum Products[2]	14	13	13
Natural Gas	32	34	32
Coal	11	10	11
Nuclear	8	9	8
Renewables	11	12	13

[1]Motor gasoline and diesel consumption for the transportation sector.
[2]Other petroleum products include liquefied petroleum gases and other; jet fuel; kerosene; distillate fuel oil use outside the transportation sector; residual fuel oil; petrochemical feedstocks; and other petroleum (e.g., aviation gasoline, road oil, misc. petroleum products).

Sources: EIA, Haver Analytics

But sentiment remains closely tied to gas prices

Lower, stable EV fueling costs could positively impact sentiment



Sources: EIA, University of Michigan, Haver Analytics

"Consumer sentiment becomes more pessimistic with rising gas prices. This effect is strongest for consumers who lived through the recessionary oil crises in the 1970s…"

– *Binder and Makridis (2022)*

"[W]e also find that aggregate demand and other oil demand shocks have significant influence on household satisfaction with economic policy measures 'to fight inflation and unemployment.'"

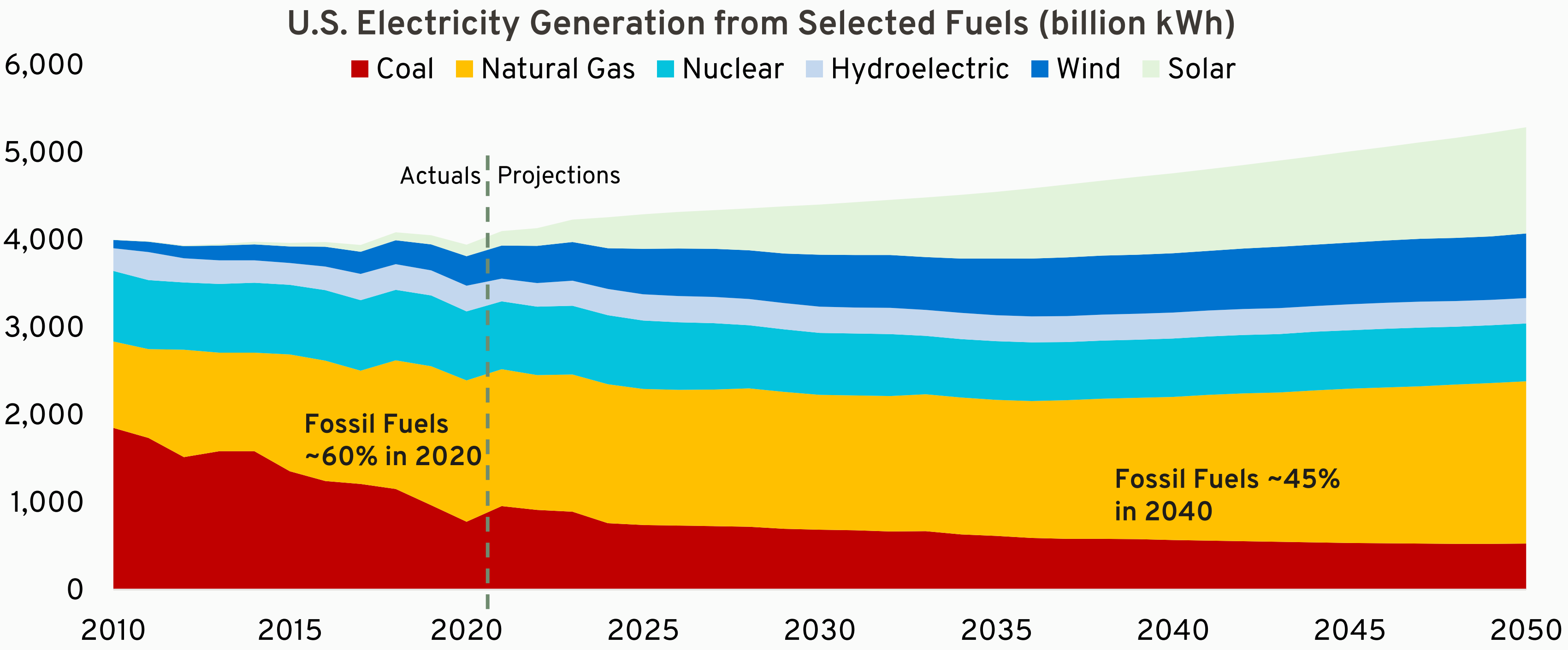
– *Güntner and Linsbauer (2018)*

"[H]istorically energy price shocks have been an important factor in explaining U.S. real consumption growth, but by no means the dominant factor."

–*Edelstein and Kilian (2009)*

Increasingly renewable U.S. electricity generation will further increase climate benefits as the U.S. vehicle fleet transitions to EVs

~60% electricity generation from fossil fuels in 2020 down to ~45% in 2040.



Sources: EIA, Annual Energy Outlook 2022, Reference case; Haver Analytics

Optimized charging can further increase the climate benefits

“**Electrifying 100% of car miles traveled** (thereby eliminating gasoline vehicle carbon emissions) increases electricity-sector carbon emissions by 23-27% if vehicles are charged at night but **could *decrease* electricity-sector carbon emissions if vehicles are charged during the day.**”

If you further net out avoided gas/diesel emissions from ICE vehicles, annual welfare gains of 100% EV adoption relative to zero EV adoption **can increase by** as much as **9%-28% with optimized charging** (i.e., charging primarily in the afternoon).

Holland, Mansur, and Yates, “Decarbonization and Electrification in the Long Run,” NBER Working Paper 30082, September 2022.

Conclusion

The EV transition reduces U.S. vulnerability to macroeconomic shocks from oil price volatility and geopolitical risk. In doing so, it should reduce economic volatility.

The EV transition shifts U.S. energy consumption **away from crude oil to self-sufficient sources** that power the U.S. electricity grid.

EV owners can expect lower and more stable fueling costs on average recognizing that there may be local variation in electricity pricing. **Avoiding gas price shocks should reduce downside to consumer sentiment.**

The climate benefits of the EV transition will increase over time as the electricity grid becomes cleaner.