



The power sector is DEAD (not really!)

The evolving power sector will impact coal

September 27, 2017

The power sector is **D...E...A...D!**

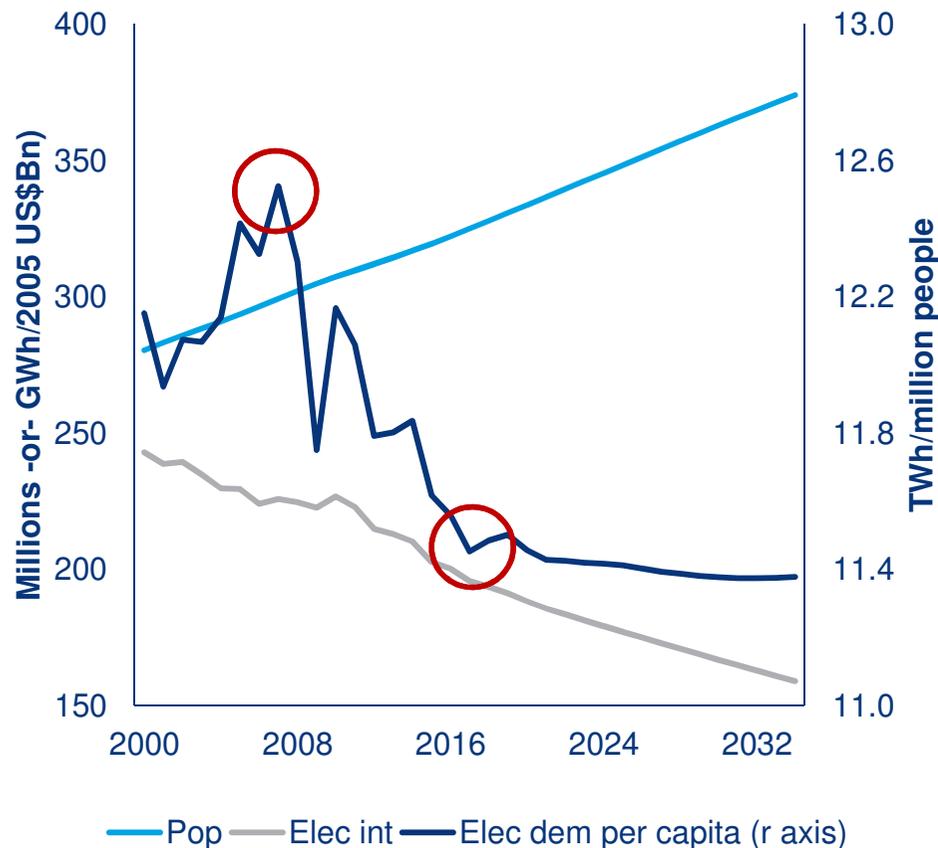
Four major trends are transforming how and why electricity is produced and distributed; these trends will forever alter the competitive environment for coal

- ◆ **D**ecarbonization
 - » Reducing emissions of GHGs
- ◆ **E**lectrification of vehicles
 - » Preparing to “fuel” the proliferation of electric vehicles
- ◆ **A**ccess to energy
 - » Bringing reliable power to everyone
- ◆ **D**ecentralization
 - » Transitioning to include dynamic, localized power grids complete with DERs

The power sector is decarbonizing

Growth in electricity sales will continue and per capita electricity growth will stabilize

Factors impacting demand for electricity in the US



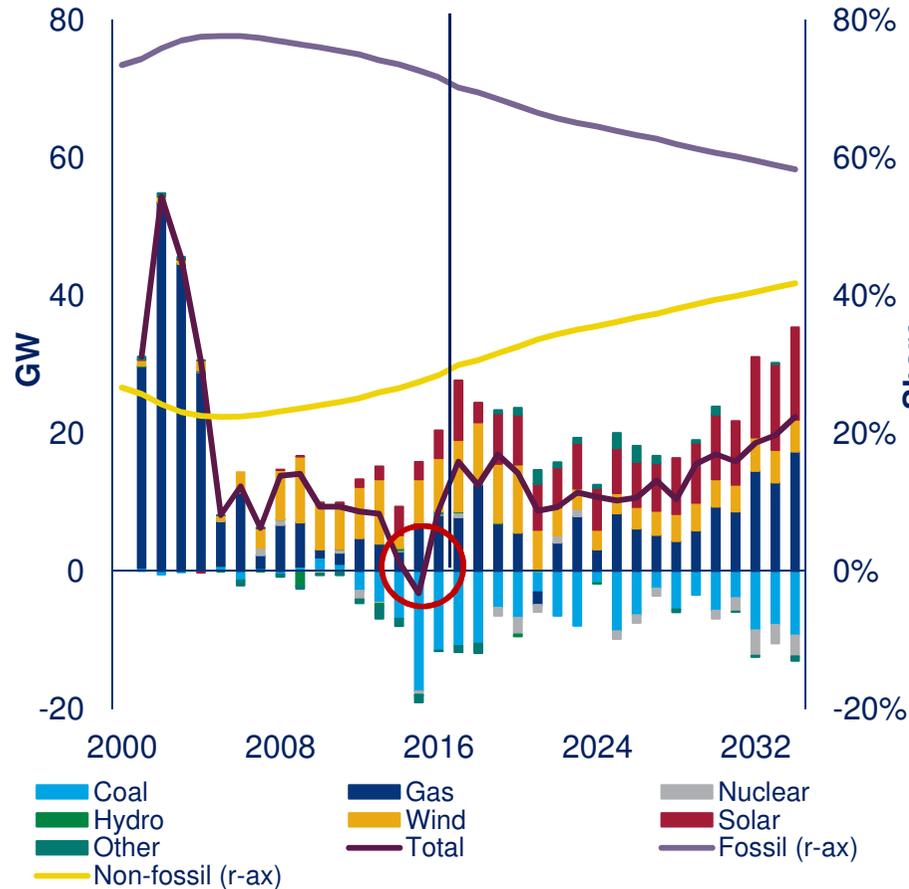
Source: Wood Mackenzie

- ◆ Indicators of increased energy demand
 - » US population is expected to grow at a rate of about 0.7% per year
 - » GDP is growing
- ◆ Indicators of decreased energy decline
 - » Electricity required to support GDP growth is falling
 - » Services-led economy
 - » Efficiency is rising
 - » Technology is improving
- ◆ Tipping points
 - » 2006
 - » 2016

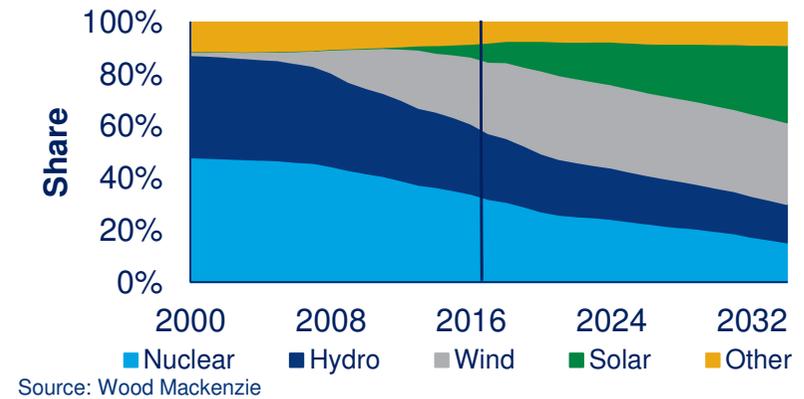
The power sector is decarbonizing

Substitute gas for coal and renewables for all

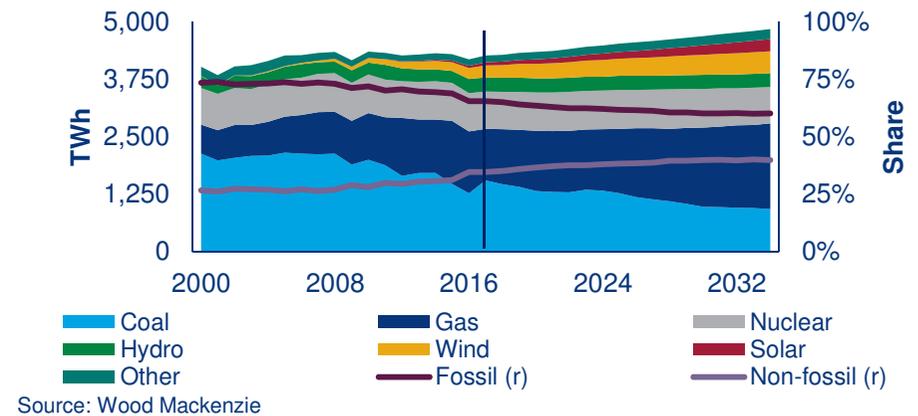
Annual change in generating capacity (GW) in the US



Capacity share of non-fossil segment (%)



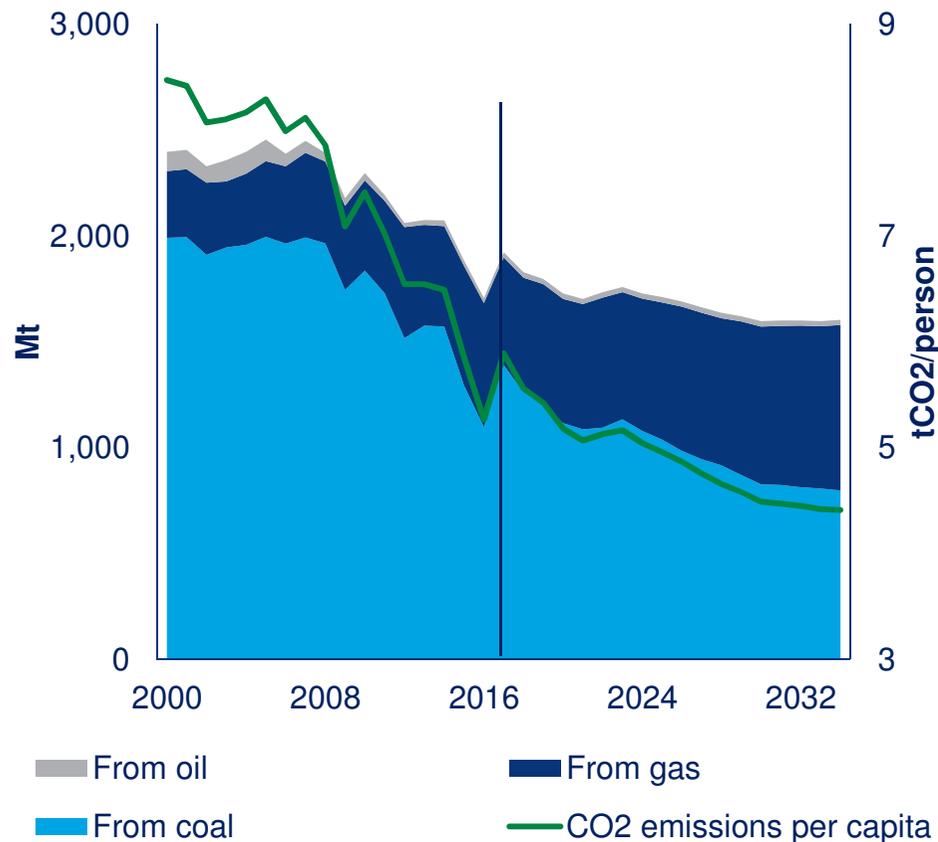
Generation by fuel type (TWh and %)



The power sector is decarbonizing

Decarbonization is coal's biggest threat, but is it an existential threat?

US power sector CO2 emissions (Mt, tCO2/person)



Source: Wood Mackenzie

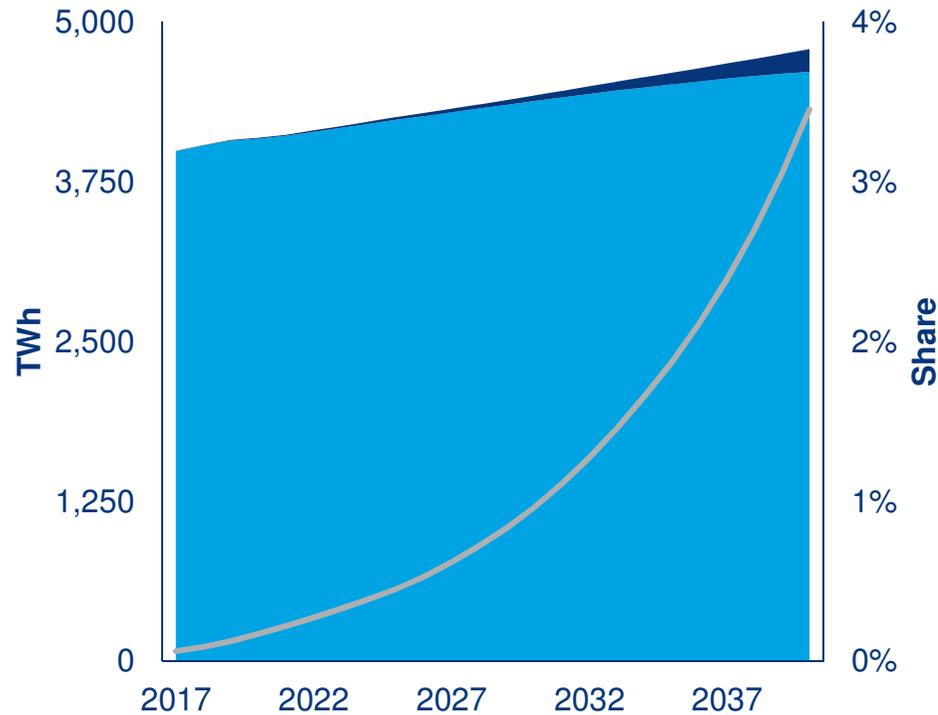
Implications for coal

- ◆ Coal fleet capacity decline
 - » Partly offset by increased coal plant capacity factors
- ◆ No new coal plant investment
- ◆ Coal consumption decline is inevitable – in the US
 - » Increased competition
 - » Strategies for survival
- ◆ But issues must be addressed
 - » How will carbon be regulated?
 - » Performance
 - » Trading
 - » Tax
 - » Migration and leakage
 - » CCS: high cost is barrier to use but is it essential?

Electricity will fuel many of tomorrow's automobiles

Market penetration of electric vehicles will be slow, in our view – but there is upside

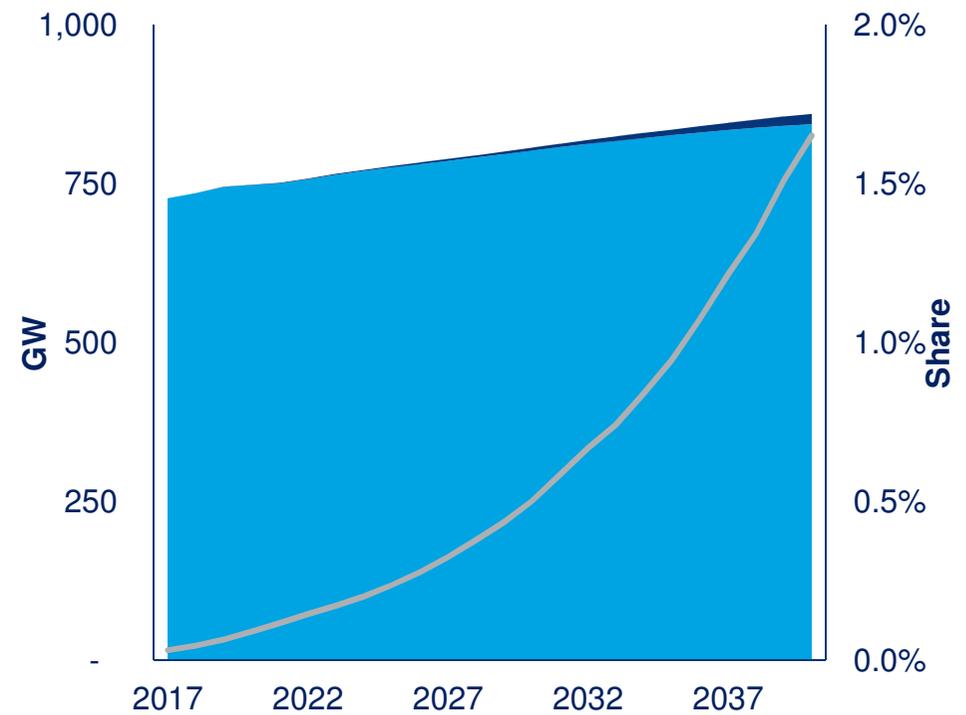
Electric vehicle electricity sales (TWh, %) in the US



■ All other sales ■ EV sales — EV sales % of total

Source: Wood Mackenzie

Electric vehicle peak demand (GW %) in the US



■ EV peak demand ■ All other peak demand
— EV peak demand % of total

Source: Wood Mackenzie

What does vehicle electrification mean to the power and coal industries?

EV market penetration will require power industry fine tuning and could be positive for coal

Power industry

- Electricity demand
 - » Increase load
- Load profile
 - » Shifting peak loads
 - » Load balancing required
- Fuel demand
 - » Which fuel?
- Power markets
 - » Price problem
- Rate design
 - » Tariffs and incentives
- Distribution grid planning
 - » Required to accommodate growth beyond what can be achieved with load balancing
 - » Reinforcement of power delivery system

Coal industry

- Bad for oil, good for coal?
- Charging
 - » When?
 - » Where?
 - » Duration?
- Likely a very small net positive

Access to electricity can be improved

Access to electricity is a global problem, not a US problem

Power industry

- ◆ What is meant by access?
 - » Providing reliable power to the hundreds of millions of people without it
- ◆ Technical solutions
 - » Grid extension
 - » Microgrids
- ◆ Policy solutions
- ◆ In the US: thinking small
 - » Providing power in small doses without extending the grid

Coal industry

- ◆ Global community with no power or intermittent power
 - » Location dependent but basically positive for coal
- ◆ US
 - » Providing power without extending the grid is a negative for coal

The availability of DERs and data will transform the grid

Tomorrow's grid could interconnect millions of devices: power plants, DERs, & consumers

Power industry

- ◆ What is decentralization?
 - » The transition to a localized network of distributed energy resources
- ◆ Examples of decentralization
 - » Distributed generation
 - » Microgrids
- ◆ Advantages
 - » Minimize transmission costs
 - » Resilience
- ◆ Issues
 - » Expensive
 - » Grid hardware and software
 - » Regulatory change
 - » Further technology development to lower costs

Coal industry

- ◆ Minimal impact
- ◆ Very small net negative

What does the evolving DEAD power sector mean for coal?

Developed world: decarbonization; developing world: access

- ◆ Decarbonizing
 - » Smaller coal fleet that is running harder but requires far less coal
- ◆ Preparing to power tomorrow's electric vehicles
 - » Small net positive impact on US coal, but years in the making
- ◆ Providing new access to powder for millions of people
 - » Large net positive impact on coal in the developing world, but no impact in the developed world (including in the US)
- ◆ Decentralizing into more flexible grids with multiple distributed energy resources
 - » Small net negative impact on US coal

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