Citi Research

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The Golden Age of Energy

An all-of-the-above strategy…in need of a unified policy

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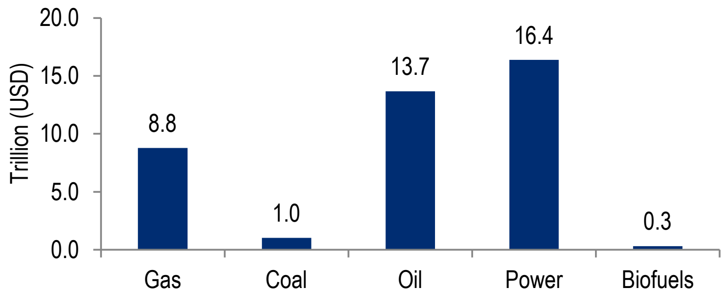
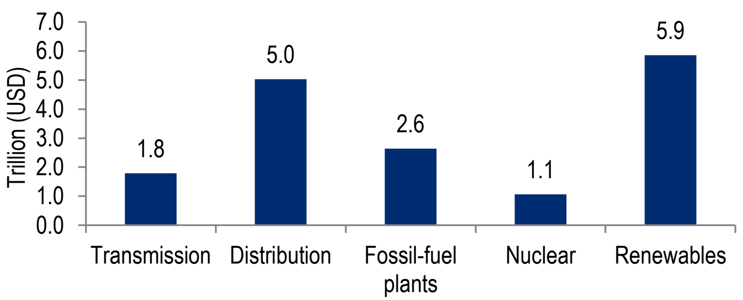
Major shifts in energy investments

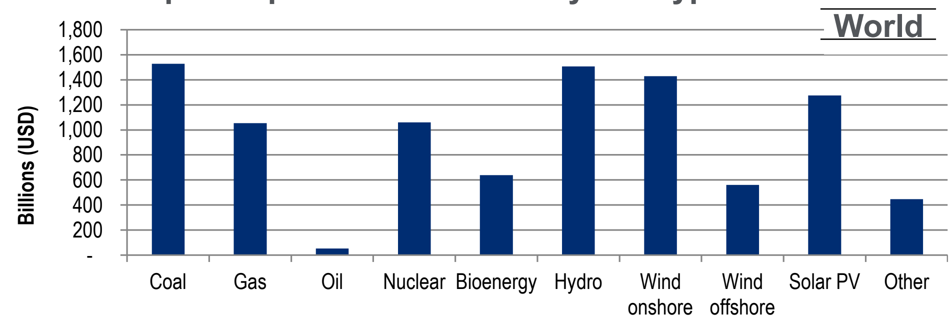
Cumulative global energy supply investment by type

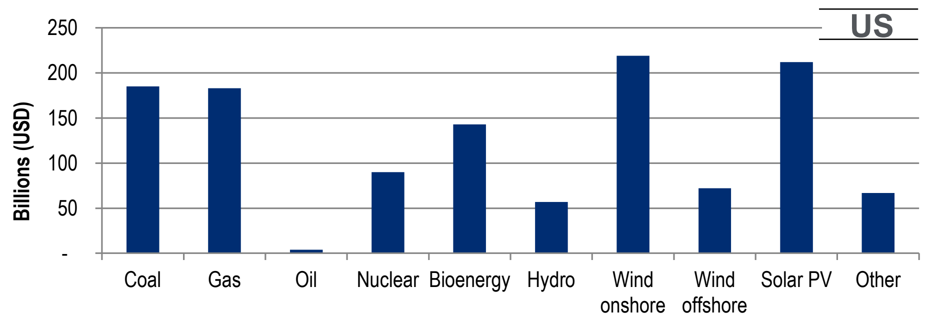


Cumulative global power investment by type

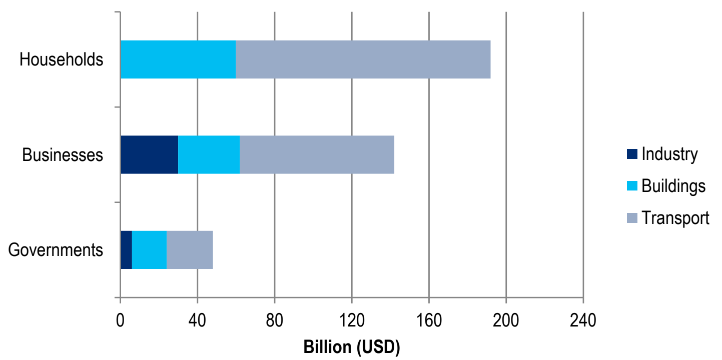


Cumulative power plant investments by fuel type





Average annual investment in energy efficiency



Energy investments undergoing substantial shifts:

- From fossil to renewables
- From larger- to smaller-scale
- From major institutions to households

Source: IEA's New Policy Scenario (2014-2035), Citi Research

US: in need of a unified energy policy

Multiple regulations

- **Energy Policy Act** (2005) – but not a unified framework;
- **Clean Air Act** (1963) and Amendments (1970, 1977, 1990)
- Many other regulations at the Federal and State levels

Multiple agencies

- Department of Energy, but also
  - Agriculture, Commerce, Defense, Environmental Protection Agency, Interior, Homeland Security, Housing, Interior, Treasury…
  - State level incentives and regulations

Some key policies:

- **Wind** growth peaked in 2012 due to uncertain policies on **Production Tax Credits;** PTCs should end by 2016 without changes to current policies
- **Solar** growth helped by **Investment Tax Credits**, but ITCs should fall in value in the next couple of years, currently at 30% of capex

Climate Action Plan – a more unified *proposal*

- National Energy Goals – Economic Competitiveness; Environmental Responsibility; Energy Security

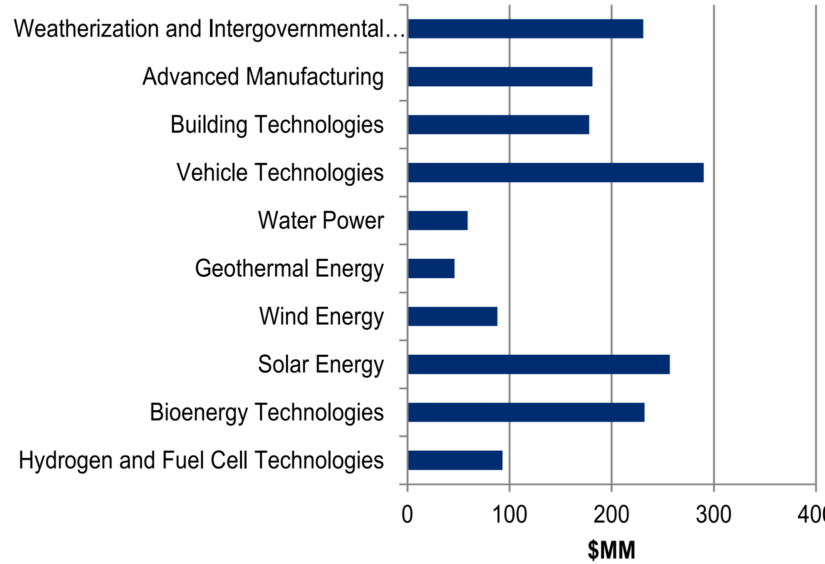
Current clean energy development helped by market forces leveraging existing policies

Source: Citi Research

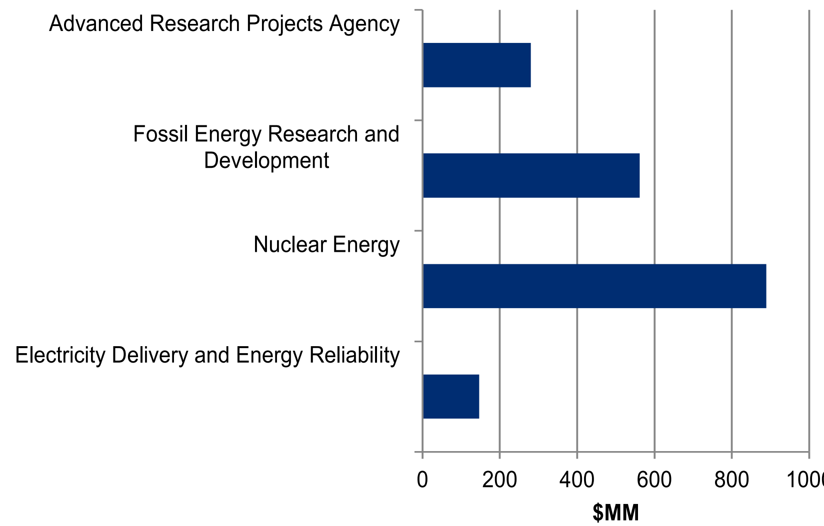
DOE policies

- **Principles for DOE's investments:**
  - **Maturity:** can still advance significantly but could reach commercial scale within a decade
  - **Materiality:** can deliver consequential impact on national energy goals
  - **Market potential:** can be adopted by markets that are driven by economics but shaped by policy
- **Transport sector:**
  - (1) Reduce oil demand, (2) promote alternative sources for transportation energy, (3) encourage technologies that fit easily into existing infrastructure, (4) reduce environmental impacts
- **Stationary sector:**
  - (1) Enhance reliability and security, (2) enable electricity management, (3) reduce environmental impacts, (4) improve information on supply and demand
- **National laboratories, partnerships with outside organizations, loan guarantee programs**

Enacted spending in the EERE division in DOE (2014)



Enacted spending in other divisions in DOE (2014)



Source: US DOE, Citi Research

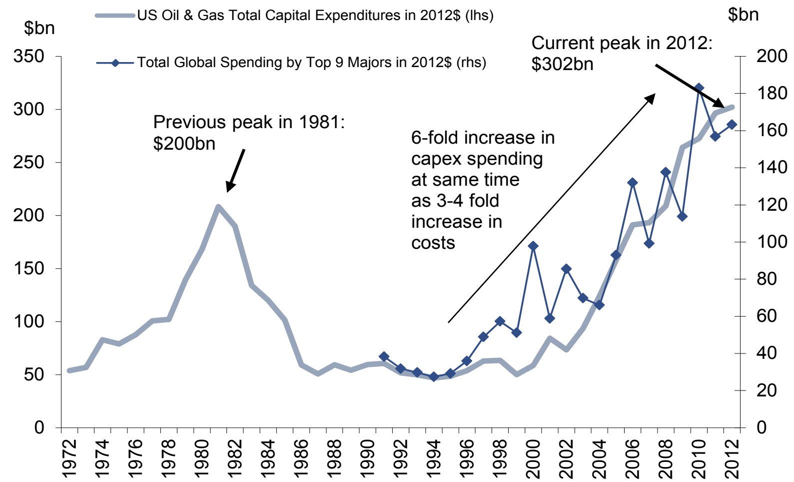
Other energy policies

	R&D	Regulation	Finance
Vehicle efficiency	NIST Transportation Programs (Commerce); Tank Automotive Research, Development & Engineering Center (Defense); Clean Automotive Technology Program (EPA); Federal Highway Administration Exploratory Advanced Research Program (Transportation)	Corporate Average Fuel Economy, or "CAFE," Standards (EPA); National Highway Transportation Safety Administration (Transportation)	Procurement (Defense); Tax Credits for electric and alternative fuel vehicles (Treasury)
Vehicle electrification	NIST Pipline Safety Testing (Commerce); Infrastructure Protection & Disaster Management (Homeland Security); Pipeline & Hazardous Materials Safety Administration (Transportation)	Clean Air Act (EPA); Right of Way permitting (Interior); Presidential permits (State); PHMSA (Transportation); Office of Energy Market Regulation (FERC); Energy commodity market regulation (CFTC)	Rural Energy for America Program (Agriculture); Renewable Fueling Infrastructure Tax Credits (Treasury)
Alternative hydrocarbon fuels	Biomass R&D initiative (Agriculture); NIST biofuels standards program (Commerce); Defense Advanced Research Projects Agency (Defense); National Vehicle & Fuel Emissions Laboratory (EPA); Research & Innovative Technology Administration (Transportation)	Renewable Fuels Standard 2 (EPA); BLM and BOEMRE leasing (Interior); Energy commodity market regulation (CFTC)	Biofuel Loan Guarantee Program (Agriculture); Defense Production Act (Defense); Tax incentives for biofuel production (Treasury)
Energy efficiency	NIST Intelligent Manufacturing Standards Program (Commerce); Defense research and engineering (Defense); Sustainable Communities Program (Housing)	Building code standards (Housing)	Rural Energy for America Program (Agriculture); PowerSavers program (Housing); Energy efficiency tax credits (Treasury)
Grid modernization	NIST energy storage & power delivery (Commerce); Defense research and engineering (Defense); Resilient Electric Grid Project (Homeland Security); Reclamation HydroPower Design and Maintenance (Interior)	NIST Smart Grid Interoperability Standards (Commerce); Transmission siting and permitting on Federal lands (Interior); Office of Electric Reliability (FERC)	Rural utility service (Agriculture); Transmission restructuring preferential tax treatment (Treasury)
Clean Electricity Generation	Ag Research Service Bioenergy program (Agriculture); NIST Power Device & Thermal Metrology Project (Commerce); Environmental Security Technology Certification Program (Defense); Air, climate & energy research program (EPA); Bureau of Reclamation Science & Technology Program (Interior)	Army Corps of Engineers licensing (Defense); Clean Air Act (EPA); BLM, BOEMRE permitting/licensing (Interior); Mine Health & Safety Administration (Labor); Nuclear reactor licensing (NRC)	Rural Energy for America Program (Agriculture); Reclamation fund (Interior); Production and Investment Tax Credits (Treasury)…

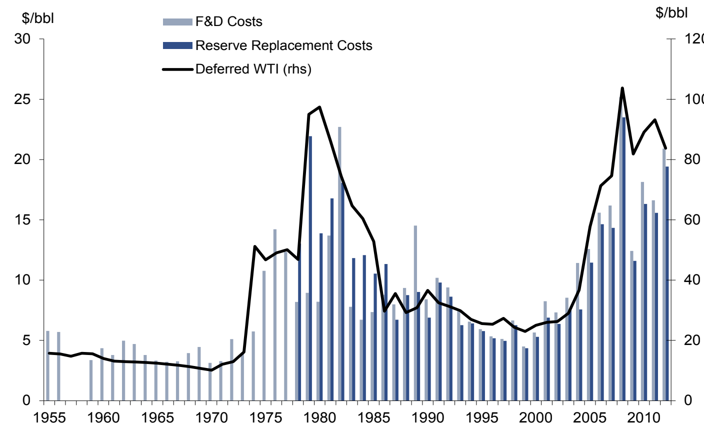
Source: US DOE, Citi Research

Traditionally, large-scale investments come in phases in the energy industry

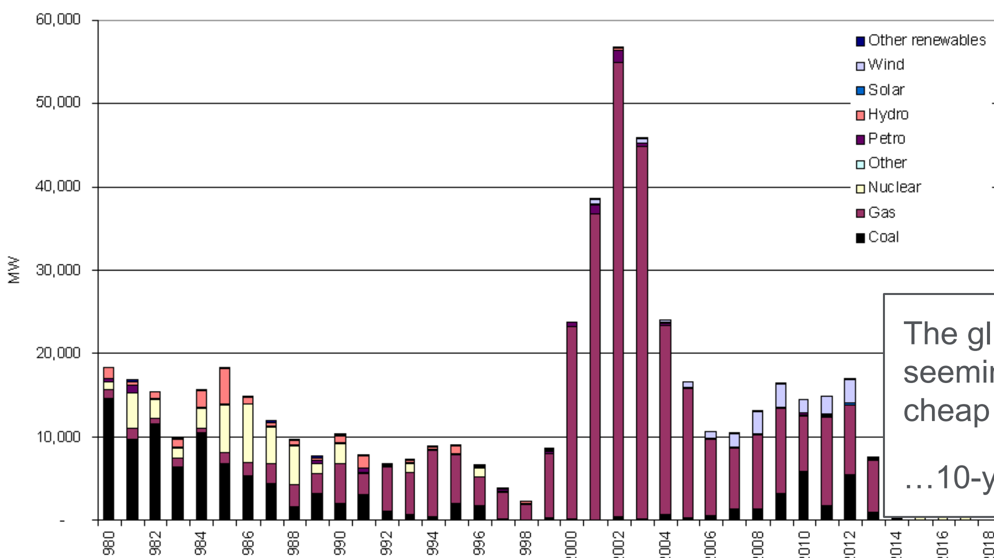
Oil and gas capex 1972-present by US, top global majors



Interplay of the oil capex and price cycles



New construction of gas power plants tapered off, now with a surplus of plants



The glut of gas-fired generation is seemingly perfectly timed to consume cheap gas in coal-gas switching…

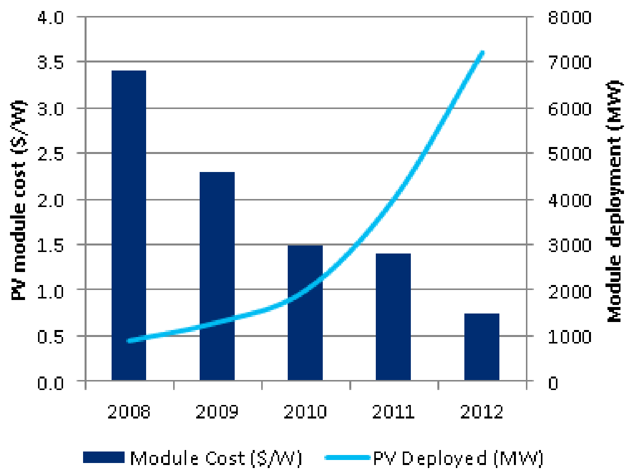
…10-years after the building boom

Source: Company reports, IHS Herold, Citi Research

Technological advances lowering cost, boosting new energy deployment

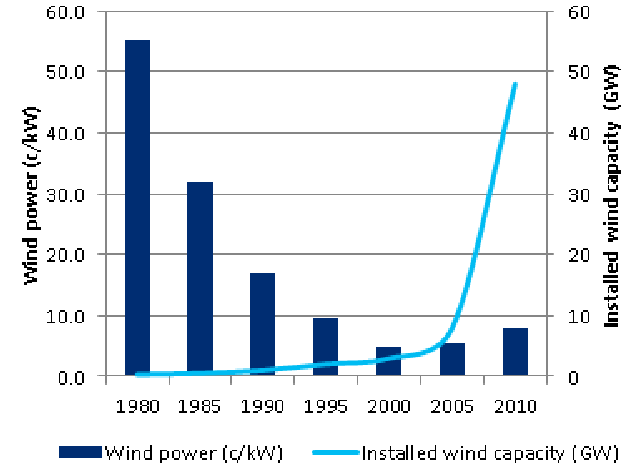
Rising deployment amid falling cost of renewables

Solar PV modules (2008-12)



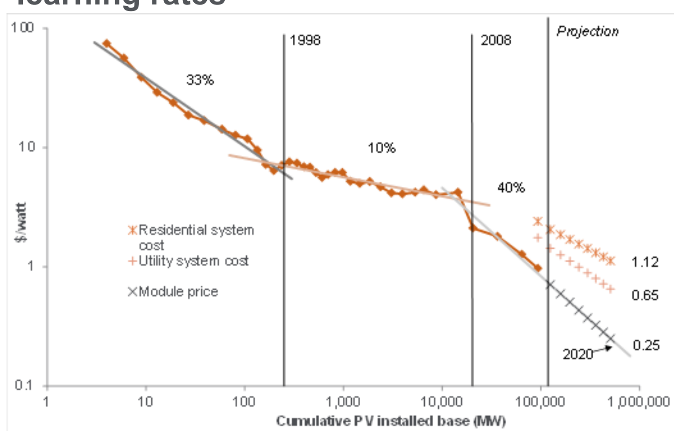
US land-based wind (1980-12)

60-GW by 2012 already

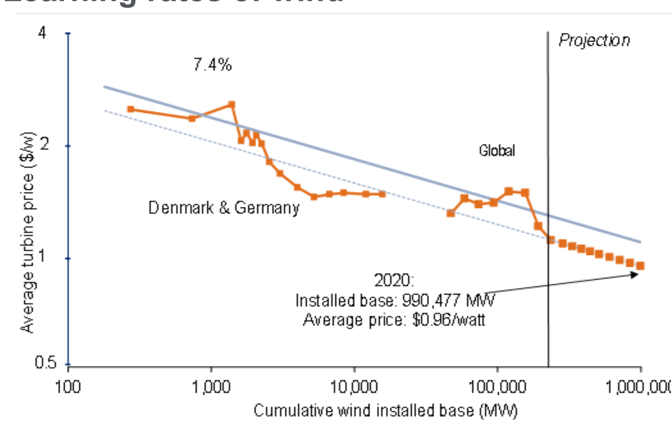


Cost reduction to continue in the future

Solar exhibits potentially rapid learning rates



Learning rates of wind



Source: DOE, Citi Research

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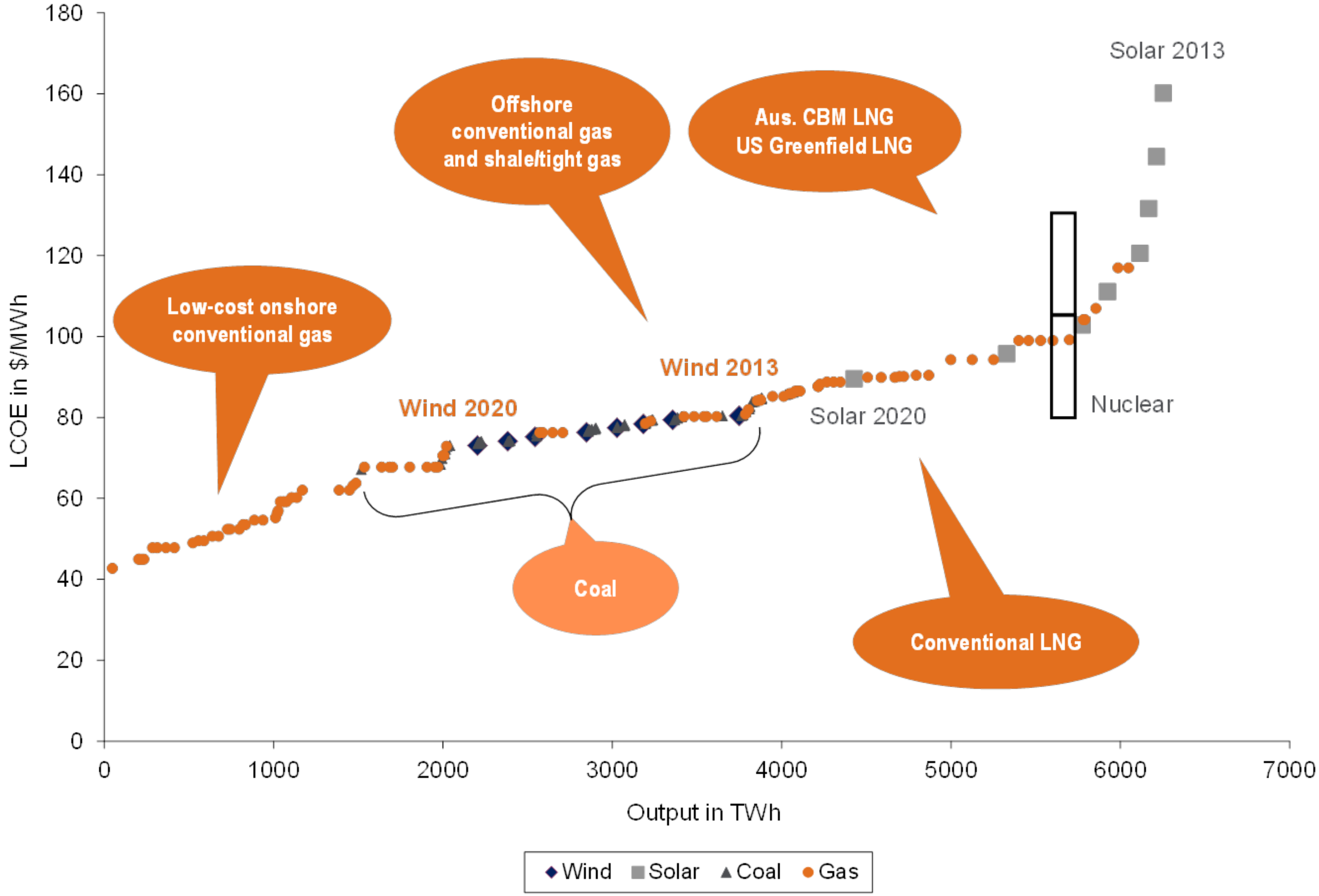
This transformation changes the cost curve: substitution to accelerate

Citi's Global Integrated Energy Cost Curve*

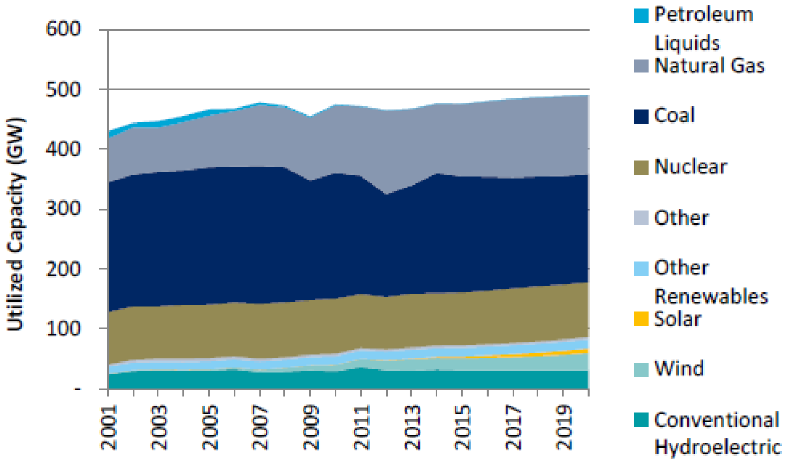


* LCOE is the 'Levelised Cost of Electricity', which attempts to compare different methods of electricity generation in cost terms on a comparable basis. Different technologies vary materially in the proportion of upfront capital expenditure vs. fuel cost or operating costs. LCOE incorporates all of these costs and calculates the 'price' of electricity needed to give a certain rate of return. The cost curve only includes export-oriented projects: the integrated global energy cost curve is built from 98 gas projects, 48 coal projects, 120 solar and 120 wind projects/scenarios, with nuclear also included.

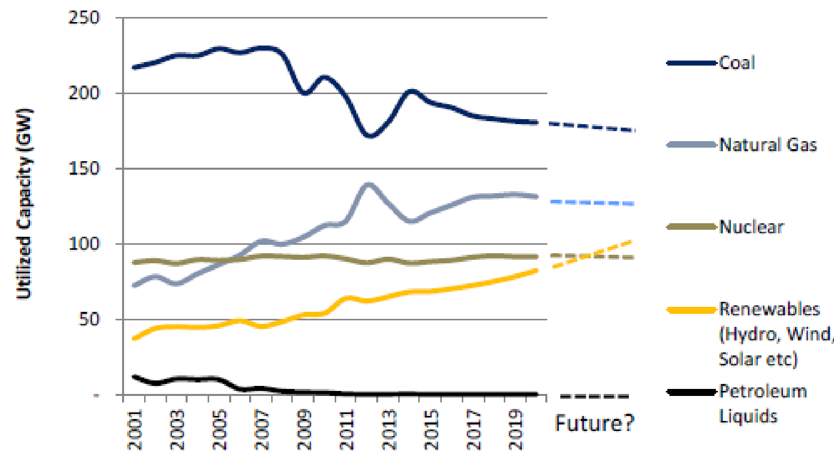
Source: Citi Research

Looks like a short gas bridge to renewables based on overall MW needed

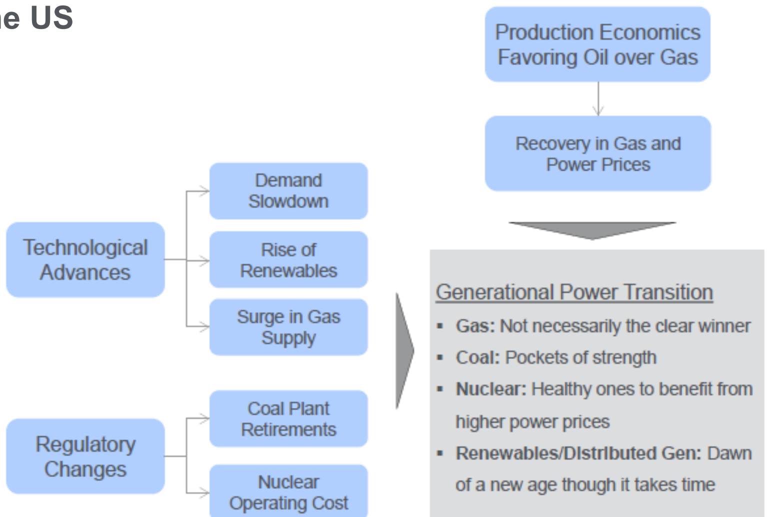
Total US generation in utilized capacity (GW) showing modest growth as demand growth stalls; coal resilient



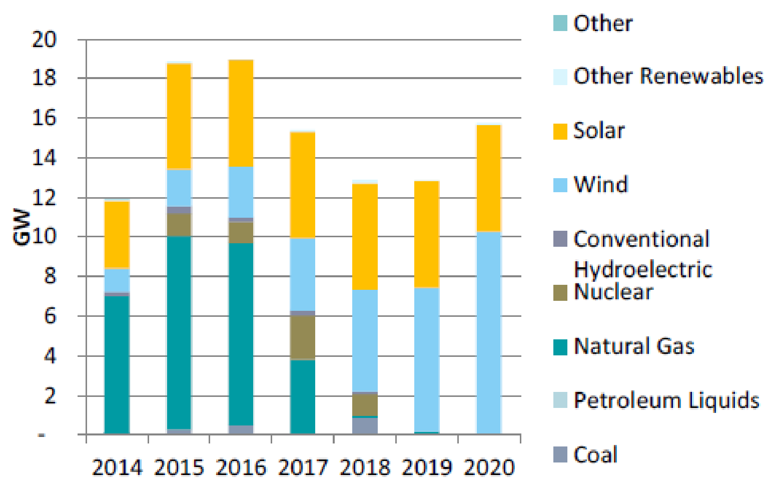
Rapid rise of renewables limits the potential for much stronger gains in gas demand



Factors driving the generational power transition in the US



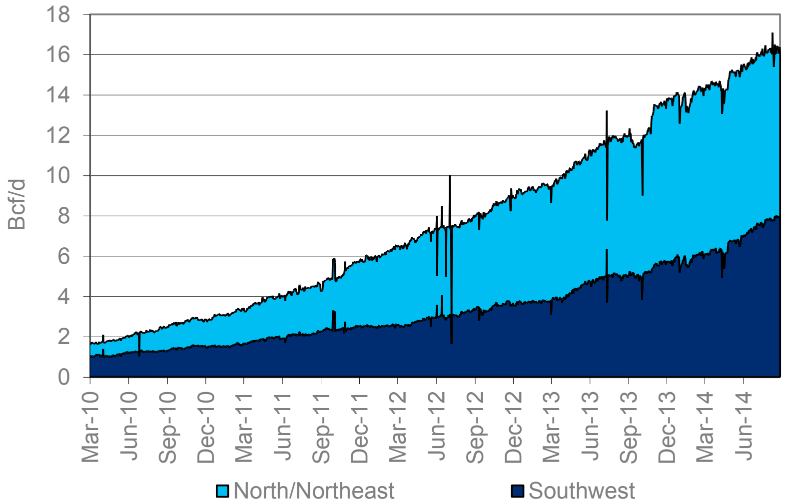
New capacity dominated by renewables and some gas: new markets for US gas may be overseas rather than domestic



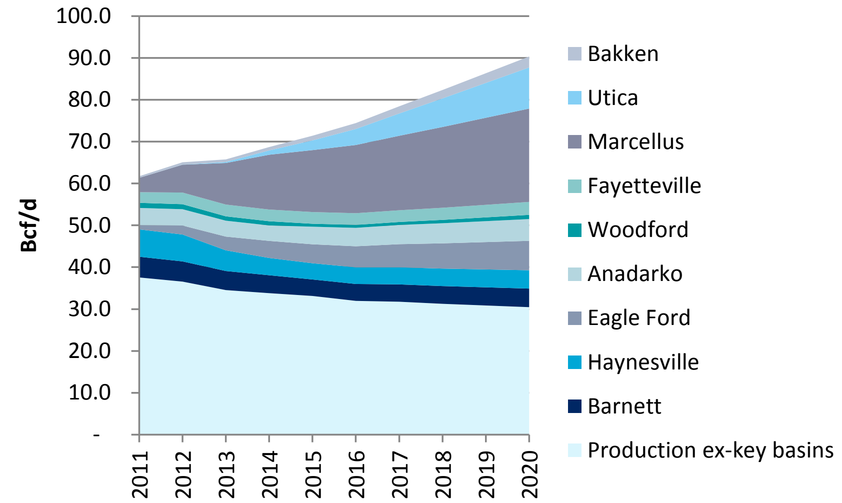
Source: EIA, Ventyx, Citi Research

But US gas growth looks sustainable as productivity continues to rise…

Northeast production rose from near minimal levels to become the 3rd largest producer after US, Russia

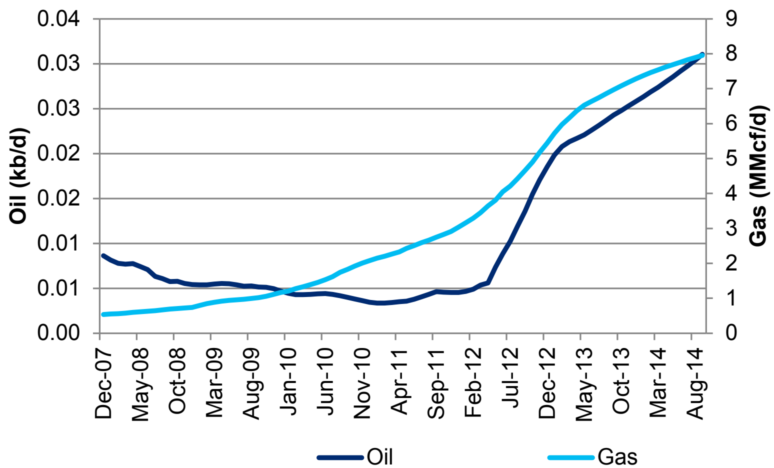


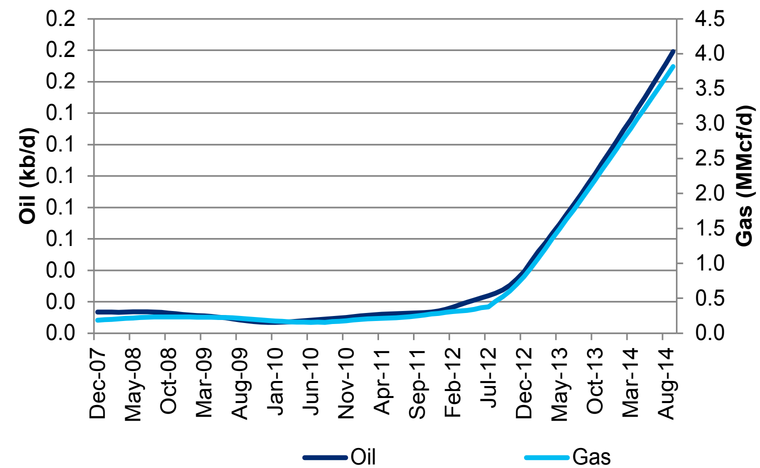
Nationally, gas production could rise by 50% between 2011 and 2020 and export growth



Much of the production growth is driven by productivity gains:

Average first month oil and gas production per rig in the Marcellus (left) and the Utica (right)

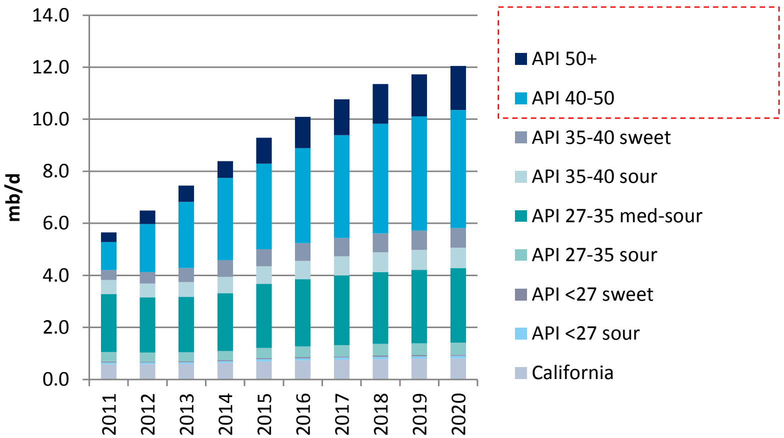




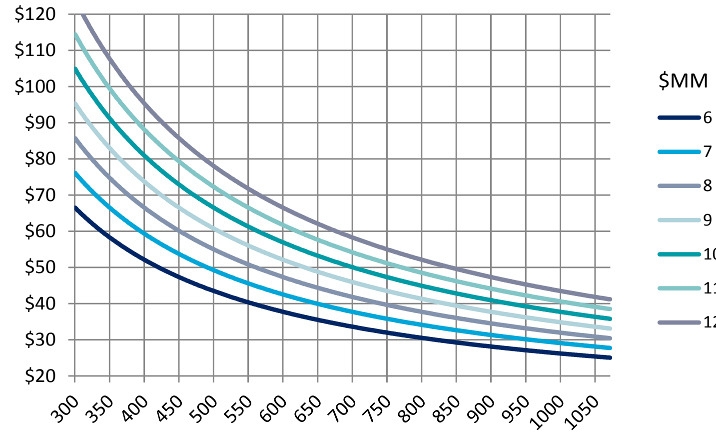
Source: EIA, Bentek, Citi Research

Oil production also rising rapidly, while fuel efficiency could slow demand gains

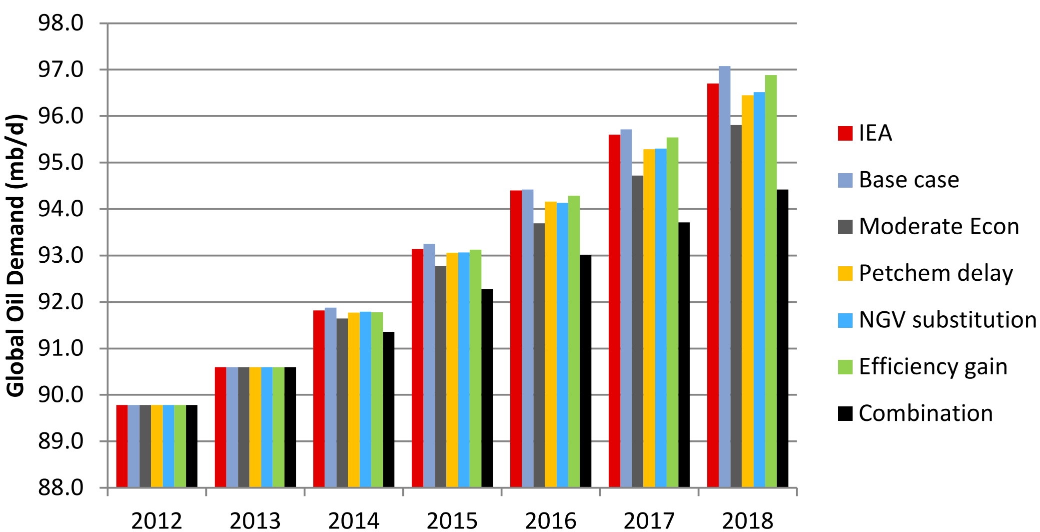
Projected growth of US crude oil production mostly from light crude (12-mb/d in total by 2020)



Very low production cost for oil possible: Eagle Ford breakeven prices for various IPs* and various well costs ($MM)



Strong business-as-usual demand growth should slow with raising efficiency



<u>Impact of the Shale Revolution</u>:

- Rising oil and gas production
- Driving down oil and gas prices
- Export opportunities to lower global prices

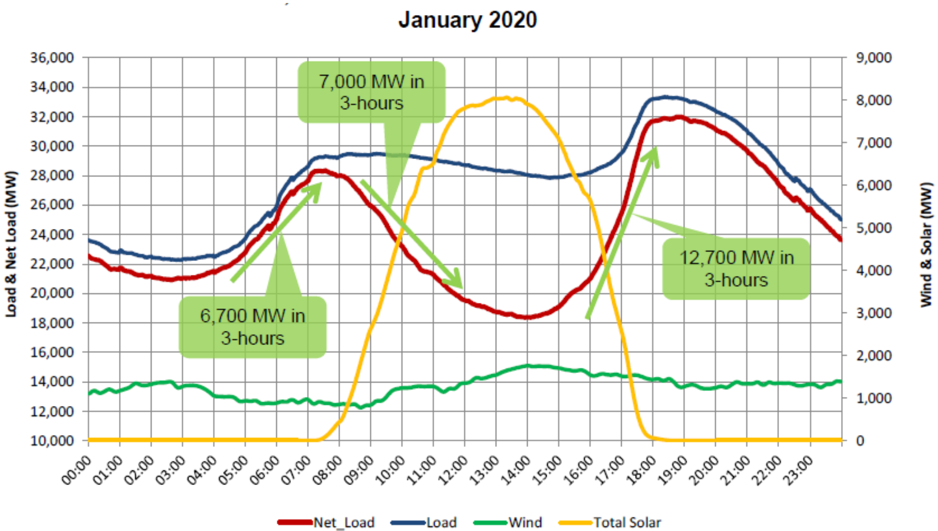
* IP = Initial Production (average production in the first 30 days)

Source: EIA, DrillingInfo, Citi Research

But renewables' intermittency require gas/storage to shape power output

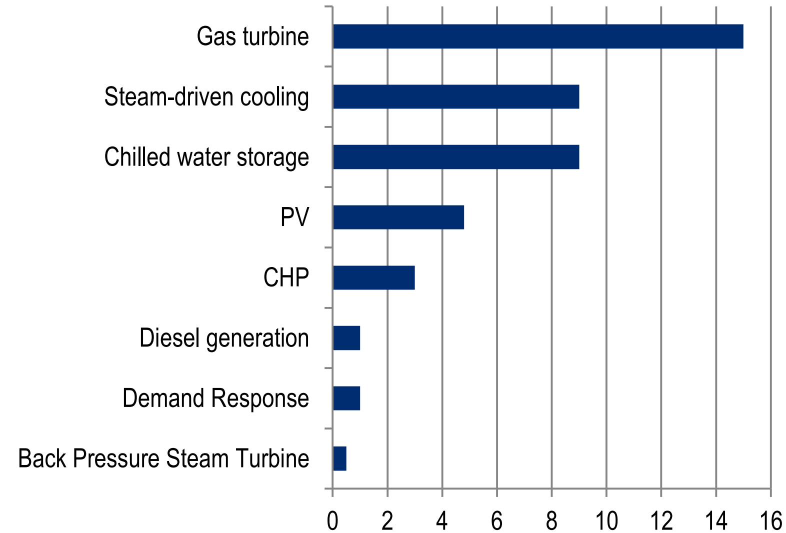
Theoretically generation and load seem rather smooth…

NERC's base scenario of load, wind and solar profiles in California



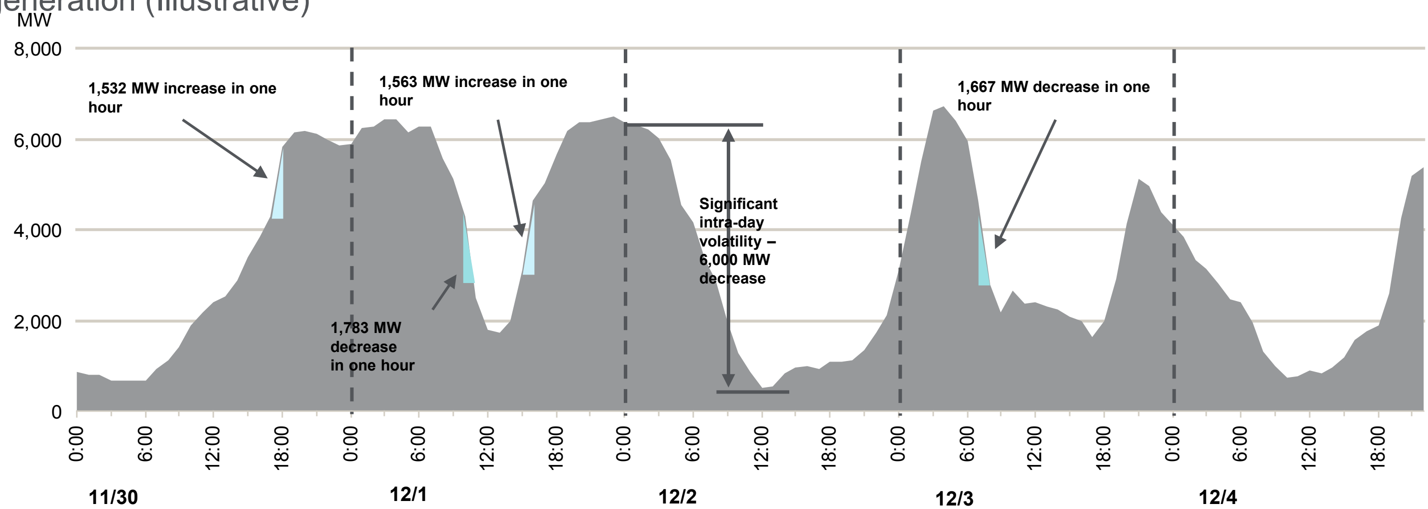
… But a microgrid needs substantial gas generation

MW breakdown of Princeton University's microgrid



And for wind, there are still kinks that require smoothing

Hourly wind generation (Illustrative)



Source: NERC, ERCOT, BNEF, Citi Research

Requirements to make renewables generation profile similar to fossils

Multiple components needed to make renewables act like fossil generation

- **Shaping**
- **Regional price spreads**
- **VGR – Variable Generation Risk**
- **Ancillaries**
- Attrition
- Hedging/ Hold-Open Risk
- Regulatory Changes
- **Data Integrity – for forecasts**

Fossil generation does require some, but all of the components

- Regional price spreads
- Attrition
- Hedging/ Hold-Open Risk
- Regulatory Changes

Source: Citi Research

Cost comparisons go beyond levelized costs of energy (LCOE)

- **A global LCOE seems to be a good way to put different energy sources on a level playing field in the power sector. This is similar to P/E ratio or VaR. But there are many problems associated with it.**
  - Wind and solar may be competitive with gas on an LCOE basis (ie, capital + operating costs), but the former needs energy storage, which adds to cost, to deliver a similar generation profile as a gas plant.
  - But using a gas plant LCOE is also not appropriate, because there is generally enough gas generation capacity that no gas plants would need to be built in most cases.
  - Hence, a more appropriate comparison should be the LCOE of wind or solar + storage vs. the marginal generation cost (ex. capital) of a gas plant, for example.
- **Some of the comparisons ignore local conditions**: coal is necessarily cheap but delivered cost is important; renewables are great but capacity factors change in different locations because the cost decline will continue on a log scale no less.
- **Technical constraints in integrating variable energy resources** do present challenges, e.g. inertia and frequency response, reactive power and other general balancing issues.
- **But there is no denying that renewables have become very competitive:**
  - One needs to see how much of the optimism is realistic.

Source: Citi Research

Utilities across the developed world are facing mounting challenges

		Europe	US	Japan
Supply-Demand Fundamentals	Weaker demand	**Efficiency**, demand-side management, lackluster economic growth and rising distributed generation all weaken demand for utility-provided electricity (distributed generation involves off grid customers generating their own power)		
Supply-Demand Fundamentals	Fuel prices fluctuations	**Now**: legacy expensive gas supply, lack of options **Future**: higher LNG supply to lower global prices	**Now**: shale gas lowered prices, spark/dark spreads **Future**: gas price recovery could boost margins again	**Now**: Expensive LNG imports **Future**: LNG prices to fall, nuclear restart to help
Supply-Demand Fundamentals / Regulatory	Environmental / carbon policies	**EU carbon** prices too low to reduce high-carbon gen but **UK's carbon** floor high enough to drive up prices	**Coal plant retirements**	**Abandon "Kyoto"** commitment without full fleet of nuclear
Supply-Demand Fundamentals / Regulatory	Rising renewables commitment	**Government support** of rising renewables/distributed generation helps sector growth but at expense of traditional utilities – stagnant demand, fewer customers **Cost recovery on infrastructure spending** (e.g. to transmit/balance renewables) is limited as authorities still want to support "green" measures first		
Regulatory	Regulatory uncertainty	**Regulatory uncertainty** with no comprehensive policies on energy/environment affects asset investment/deployment strategy (e.g. EU gas plants, Japan nuclear)		

Source: Citi Research

Financing options are expanding based on different needs

Key sources of financing for larger scale investments

- Self-financing
  - Retained earnings
  - State budget allocation
- Banks
  - Lend on a short or long term basis
- Capital markets
  - Debt
  - Equity
  - YieldCo
- PPA-type financing

Key sources of financing for smaller scale/energy efficiency investments

- Self-financing
- Consumer loan
- Energy savings performance contract
- Energy service agreement
- Property assessed clean energy
- Utility on-bill financing
- Public loan programs
- Mortgage-backed financing

Source: Citi Research

Appendix A-1

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