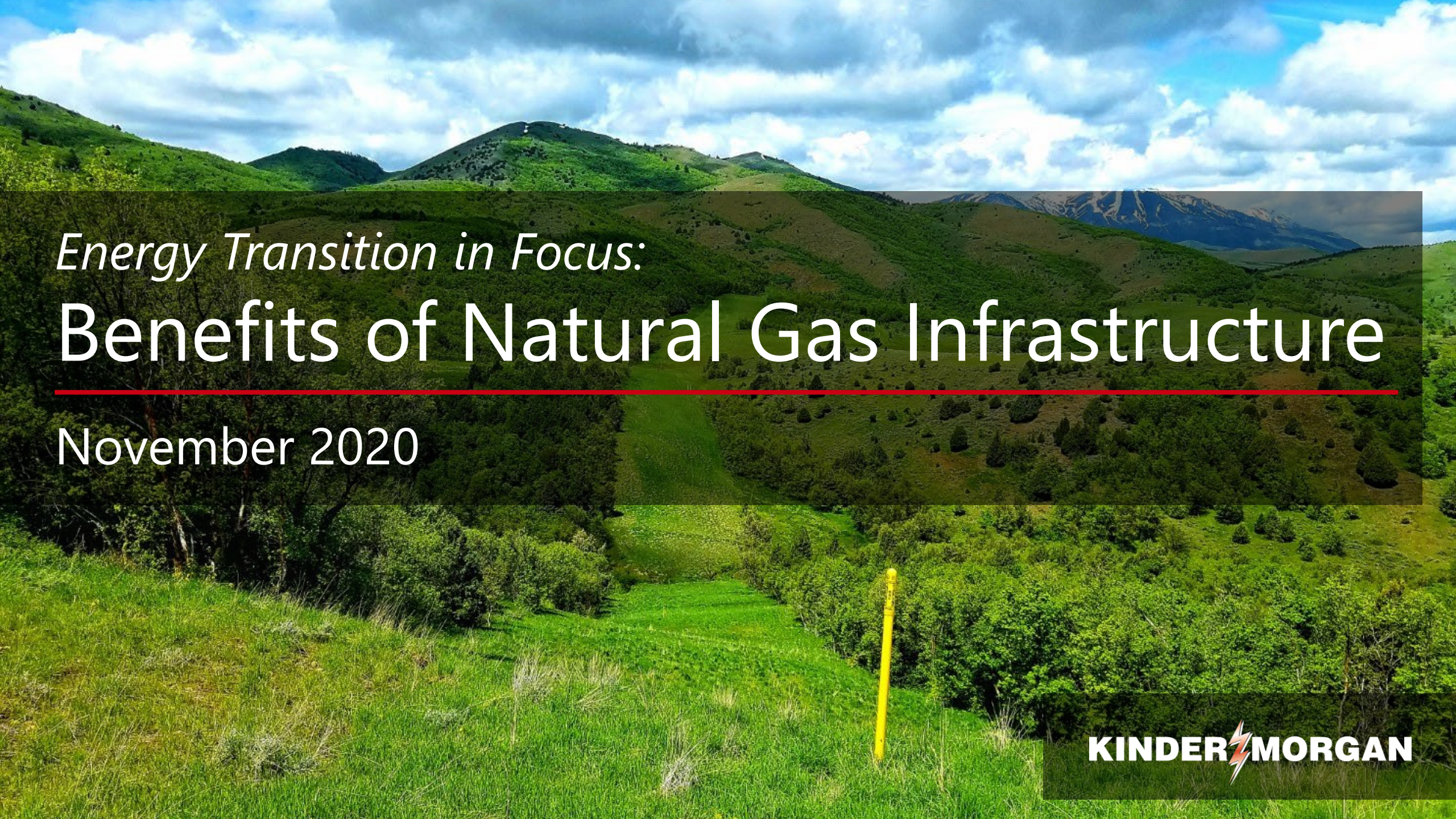


*Energy Transition in Focus:*

# Benefits of Natural Gas Infrastructure

November 2020

KINDER MORGAN

# Disclosure

## Forward looking statements / third-party data

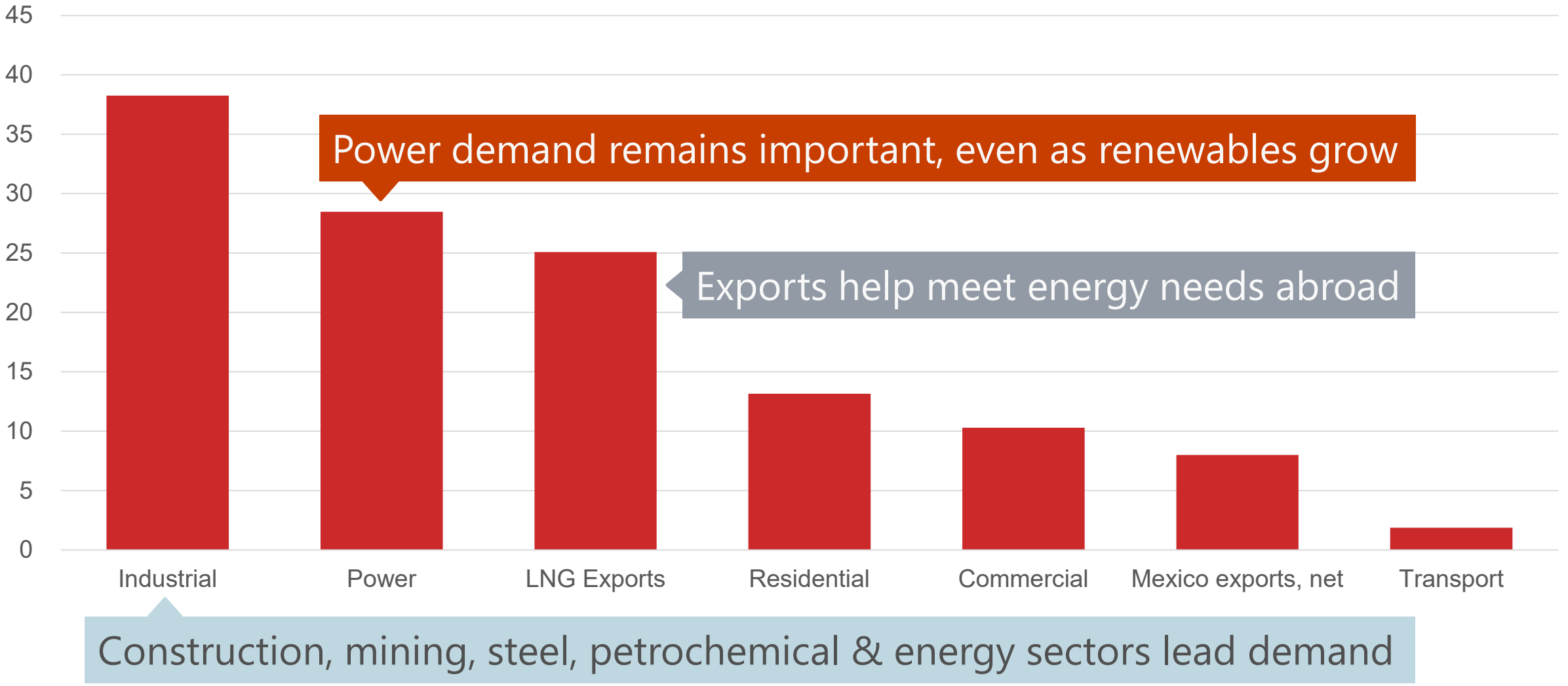
**General –** The information contained in this presentation does not purport to be all-inclusive or to contain all information that prospective investors may require. Prospective investors are encouraged to conduct their own analysis and review of information contained in this presentation as well as important additional information through the Securities and Exchange Commission's ("SEC") EDGAR system at www.sec.gov and on our website at www.kindermorgan.com.

**Forward-Looking Statements –** This presentation includes forward-looking statements within the meaning of the U.S. Private Securities Litigation Reform Act of 1995 and Section 21E of the Securities Exchange Act of 1934 ("Exchange Act"). Forward-looking statements include any statement that does not relate strictly to historical or current facts and include statements accompanied by or using words such as "anticipate," "believe," "intend," "plan," "projection," "forecast," "strategy," "outlook," "continue," "estimate," "expect," "may," "to," "will," "shall," and "long-term". In particular, statements, express or implied, concerning future actions, conditions or events, including long term demand for our assets and services and opportunities related to alternative energy sources are forward-looking statements. Forward-looking statements are not guarantees of performance. They involve risks, uncertainties and assumptions. There is no assurance that any of the actions, events or results of the forward-looking statements will occur, or if any of them do, what impact they will have on Kinder Morgan. Because of these uncertainties, you are cautioned not to put undue reliance on any forward-looking statement. We disclaim any obligation, other than as required by applicable law, to publicly update or revise any of our forward-looking statements to reflect future events or developments.

**Industry and Market Data –** Certain data included in this presentation has been derived from a variety of sources, including independent industry publications, government publications and other published independent sources. Although we believe that such third-party sources are reliable, we have not independently verified, and take no responsibility for, the accuracy or completeness of such data.

# Broad Demand for Natural Gas Expected to Continue

Forecasted U.S. Natural Gas Demand by Sector in 2040 (Bcfd)




Source: WoodMackenzie Summer 2020 Long Term Outlook. Industrial includes WoodMackenzie's "Other" category, comprised of lease and plant fuel in the oil and gas sector, as well as fuel used for liquefaction at LNG export facilities.

# Natural Gas Complements Renewables

Clean energy is accelerating due to technological advancements & global climate change initiatives



## BENEFITS OF NATURAL GAS

### LOW EMISSIONS

Natural gas is the cleanest burning fossil fuel with significantly lower emissions than coal or fuel oil

Switching from coal to natural gas has driven a substantial reduction in the nation's power sector $CO_2$ emissions

Helps meet environmental targets

### ABUNDANT & LOW COST

Cost-effective generation

Helps maintain affordability for consumers

### RELIABLE

Provides energy supply when renewable sources are intermittent

Can be dispatched quickly

### ENERGY DENSE & EFFICIENT

Less land area required compared to alternative energy sources

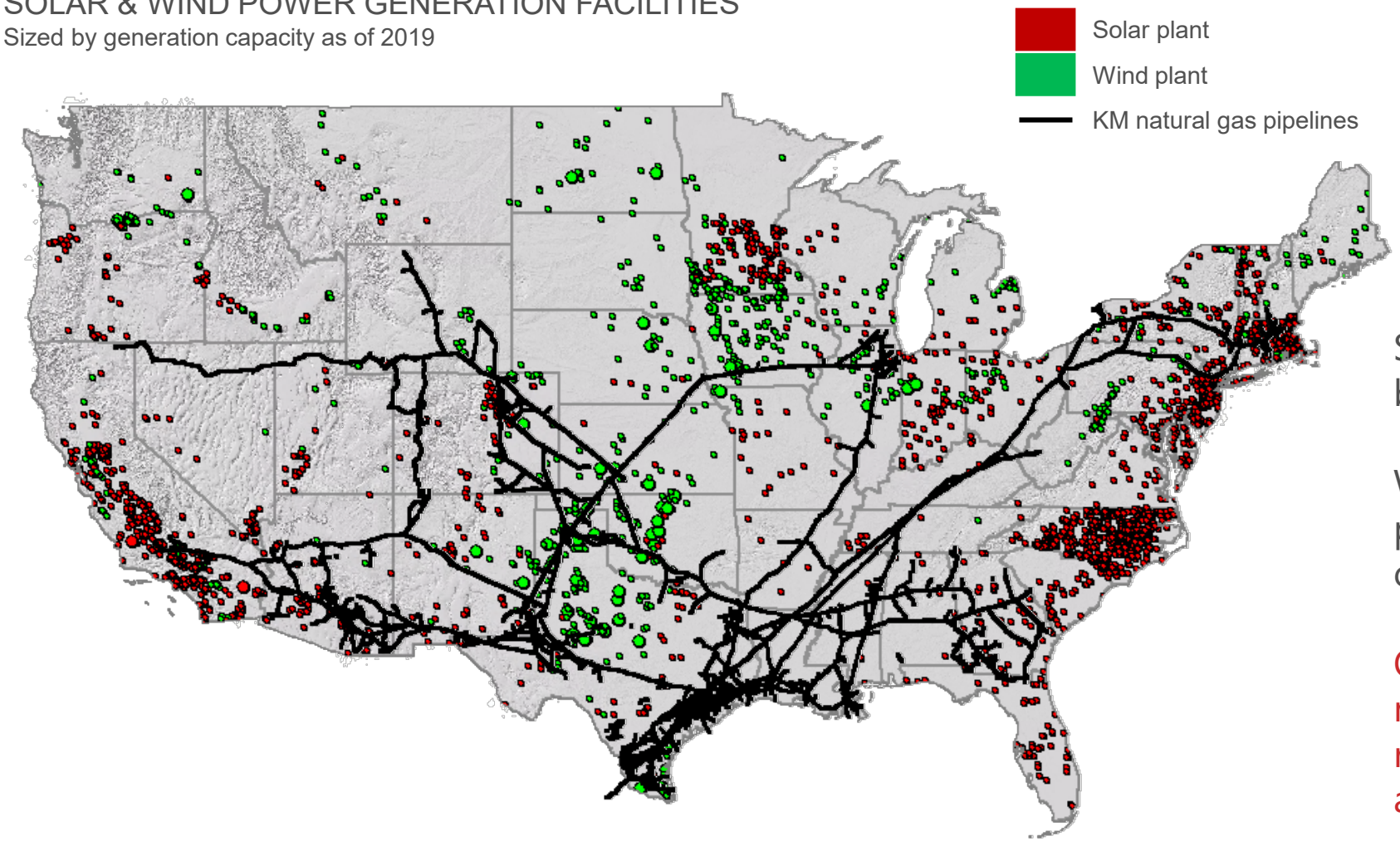
Helps avoid additional land disturbances

# We Serve Regions with Meaningful Renewable Power Today

Our tailored deliverability services better support the needs of flexible grids in these areas

## SOLAR & WIND POWER GENERATION FACILITIES

Sized by generation capacity as of 2019




Solar power generation tends to be concentrated along the coasts

Wind power generation most prominent in the interior of the country

Our extensive natural gas pipeline network spans both of these regions & supports customers who are firming renewable power assets

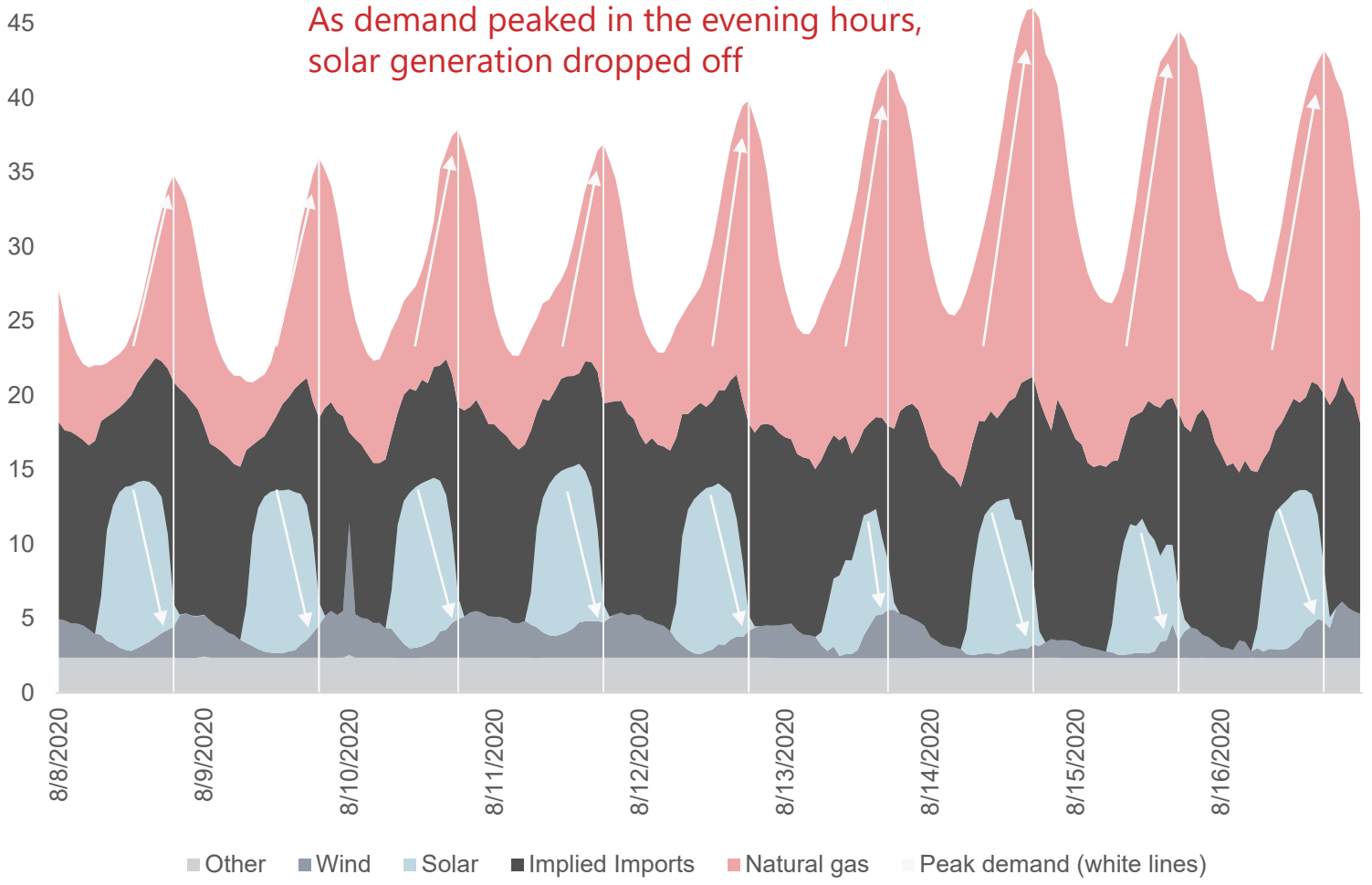
Source: Hitachi ABB Velocity Suite Monthly Plant Generation.

# RELIABILITY

# Natural Gas Steps In when Renewables Drop Out

## Case study – California blackouts

CALIFORNIA POWER GENERATION BY SOURCE
Gigawatts




During a recent **summer heat wave**

*Heat wave week average vs. prior week average*

| | |
|---|---|
| Demand | +21% |

**while…**

| | |
|---|---|
| Wind | -58% |
| Solar | -25% |
| Natural gas | +84% |
| Imports | +10% |

Adequate natural gas generation capacity could have prevented the need to curtail power

Source: U.S. EIA Hourly Electric Grid Monitor. "Other" includes generation from coal, petroleum, hydro, and nuclear.

# Renewable Growth Requires Operational Flexibility

Infrastructure increasingly must ramp up & down quickly rather than run steady

## OPERATIONAL FLEXIBILITY

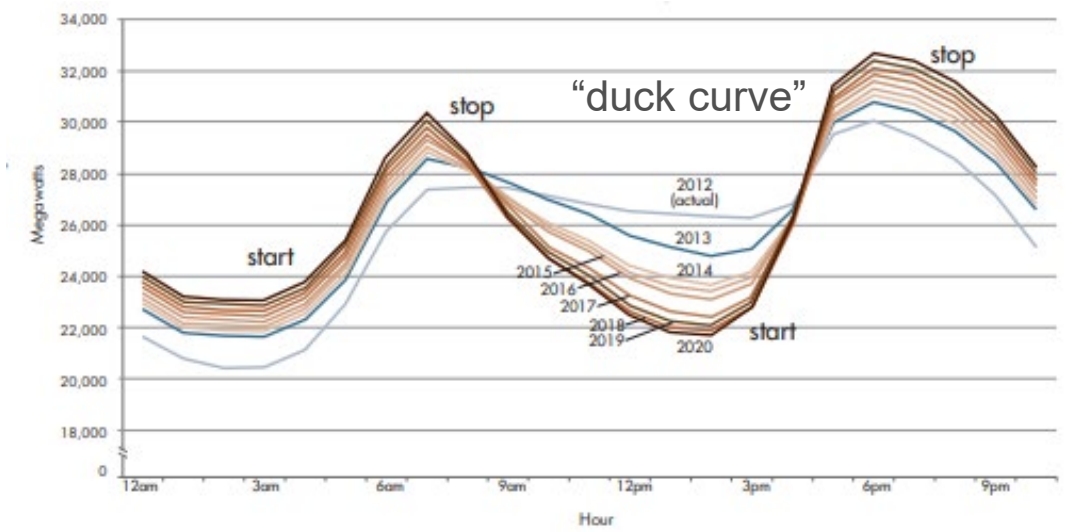
- Changes in electricity demand & generation must be constantly balanced to maintain power system stability & reliability
- Operational flexibility refers to the ability of a power system to respond to these changes
- Flexibility is particularly important for power systems that integrate high levels of solar & wind since those power sources can be variable & uncertain

## DEMONSTRATED BY DUCK CURVE

- Curve illustrates daily net load (total load less load generated from renewables) over several years
- Each year the lines are getting pushed further in each direction throughout the day
- Highlights the increasing need for flexibility in their power grid as their renewable penetration continues to increase

## CAISO DEMAND UNMET BY RENEWABLES

Net load



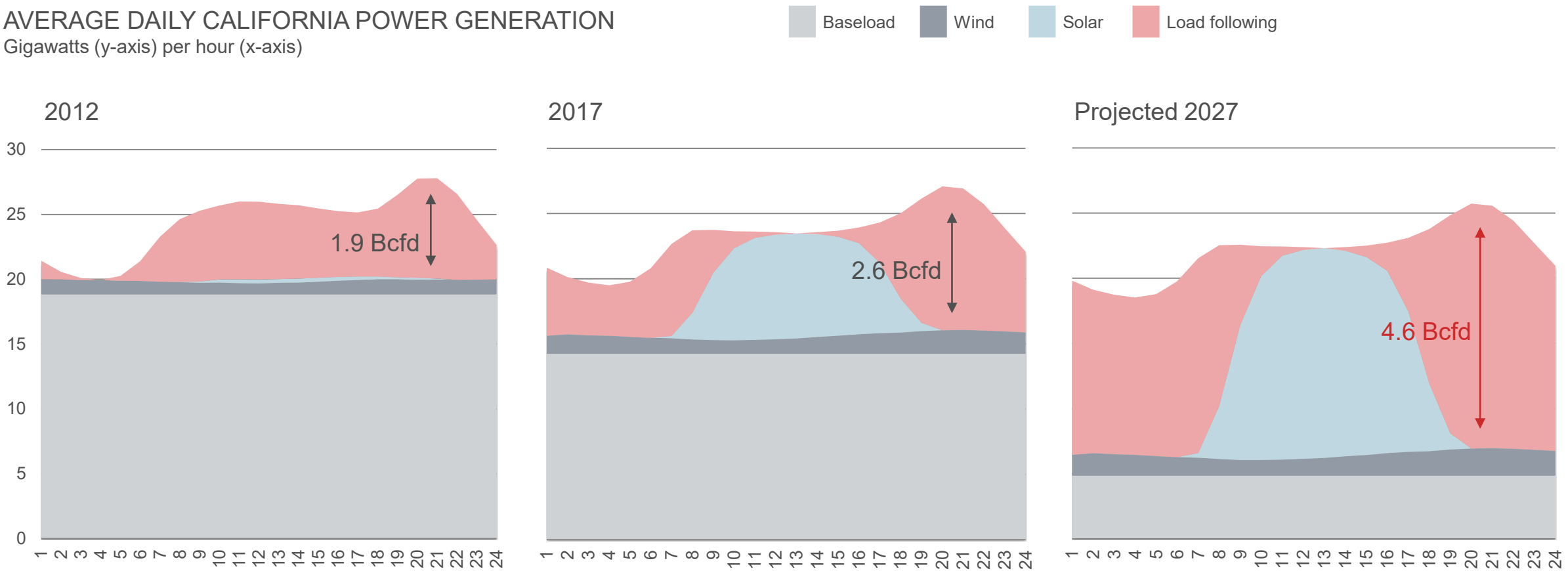

Natural gas systems can rapidly increase & decrease output, providing the operational flexibility required to back up renewables

Source: National Renewable Energy Laboratory (NREL), California Independent State Operator (CAISO).

# Renewable Growth Requires Operational Flexibility

Uniform generation is displaced by variable generation from renewables & quick-starting gas-fired generation

AVERAGE DAILY CALIFORNIA POWER GENERATION
Gigawatts (y-axis) per hour (x-axis)




Load following peak hour equates to **1.9 Bcfd**
Very manageable natural gas deliverability

Load following peak hour equates to **2.6 Bcfd**
Natural gas deliverability becomes more challenged

Load following daily average now **exceeds baseload**
Significant infrastructure capacity required to ensure natural gas deliverability at peaks

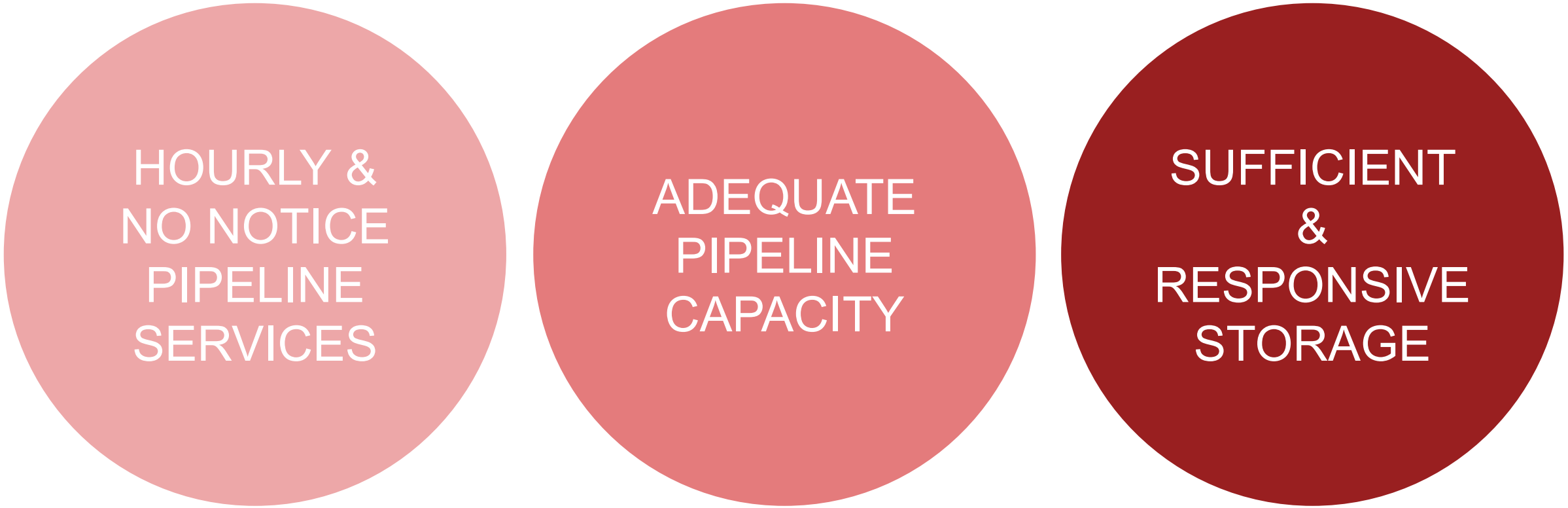
Sources: CAISO, KM analysis.
Note: Baseload generation historically has included various amounts of coal, hydro, nuclear & natural gas-fired generation. Load following in this example is natural gas-fired generation.

# ENHANCING PIPELINE DELIVERABILITY

# Enhanced Natural Gas Deliverability Optimizes Flexible Grids

With proper coordination, gas-fired generation can be dispatched optimally to meet multiple important objectives

Key components to supporting an electric grid with increasing levels of wind & solar:




Meet demand at lower cost & lower emissions while maintaining reliability

# Pipelines Have Managed Demand Variation for Decades

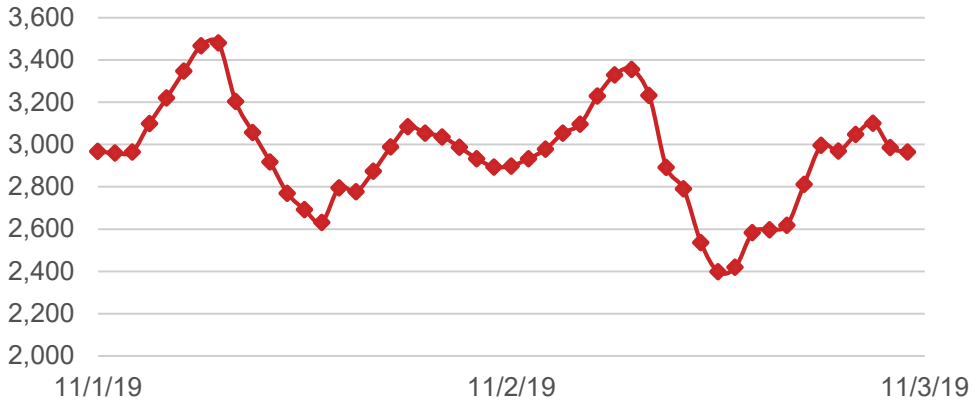
However, fluctuations in variable power generation are becoming more dramatic

- Pipelines serve Local Distribution Companies (LDCs)
  - LDCs supply natural gas directly to homes & businesses, primarily for space heating
  - Demand varies due to temperature changes throughout the day
  - Hourly usage typically follows a consistent pattern
- Pipelines serve power generation companies
  - Hourly usage can vary significantly day to day
  - Daily usage dependent on ambient conditions
  - Pipelines have historically managed these types of fluctuations in demand profiles

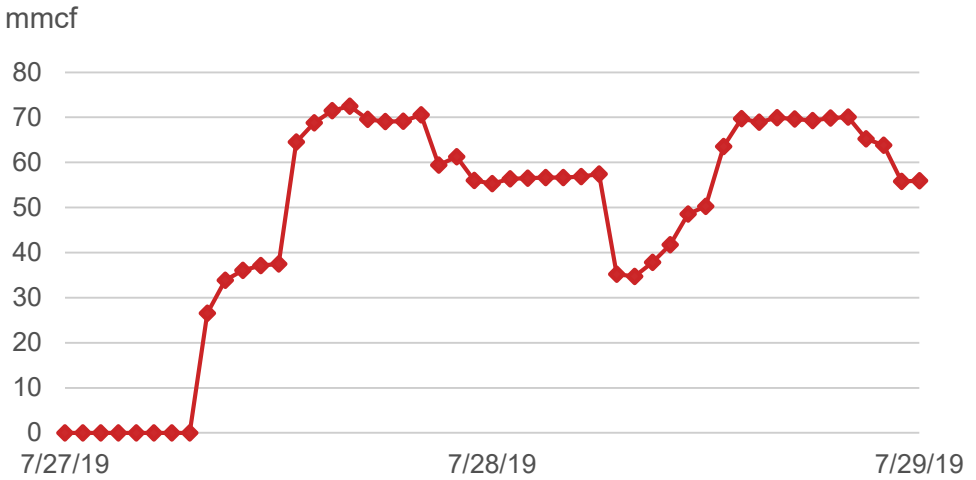
However, demand variations are now increasing in flexible power grids with growing amounts of renewable generation

Requires nearly instantaneous ramps of natural gas-fired generation — up & down — to firm renewable generation

DELIVERIES TO LDCs ACROSS THE CIG SYSTEM




DELIVERIES TO POWER GEN. ACROSS THE CIG SYSTEM




Source: Kinder Morgan data.

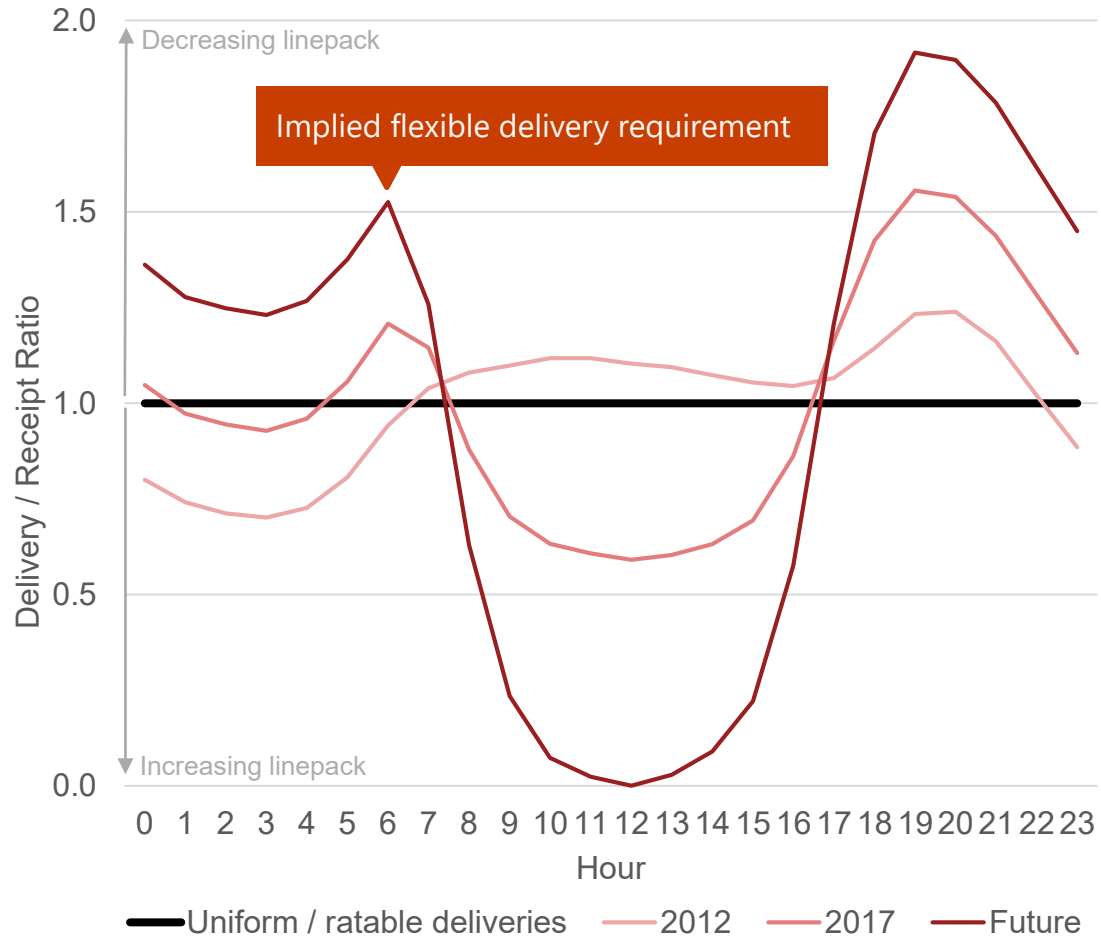
# Pipelines Must Manage Large Swings in Usage

Gaps between demand & renewable generation create challenges for natural gas deliverability

- Ideally, pipelines receive & deliver a uniform volume of gas throughout the day in order to maximize the total amount transported
  - Depicted as the black line on the graph: the 1:1 delivery/receipt ratio
  - Uniform or “ratable” deliveries have never been completely realized as natural gas demand has always varied throughout the day & year
  - However, historical fluctuations are not nearly as dramatic as what is happening with growing renewable generation
- Dramatic changes throughout the day depicted by the red lines reflect the fluctuating demand for natural gas when acting as a backstop to renewable generation
  - Above the 1:1 delivery/receipt ratio, pipelines must draw supply from storage & linepack (volume of gas stored in the pipeline)
  - Below the 1:1 delivery/receipt ratio, pipelines must store excess natural gas on the pipeline
  - To manage these swings, pipeline operators need adequate capacity to meet pressure, time, location & firm volume requirements

**Linepack management becomes important for pipeline operators, particularly in areas with insufficient storage**

CAISO HOURLY NATURAL GAS DELIVERABILITY




Source: KM analysis, CAISO duck curve.
Note: Future duck curve represented 2027 at the time of the analysis.

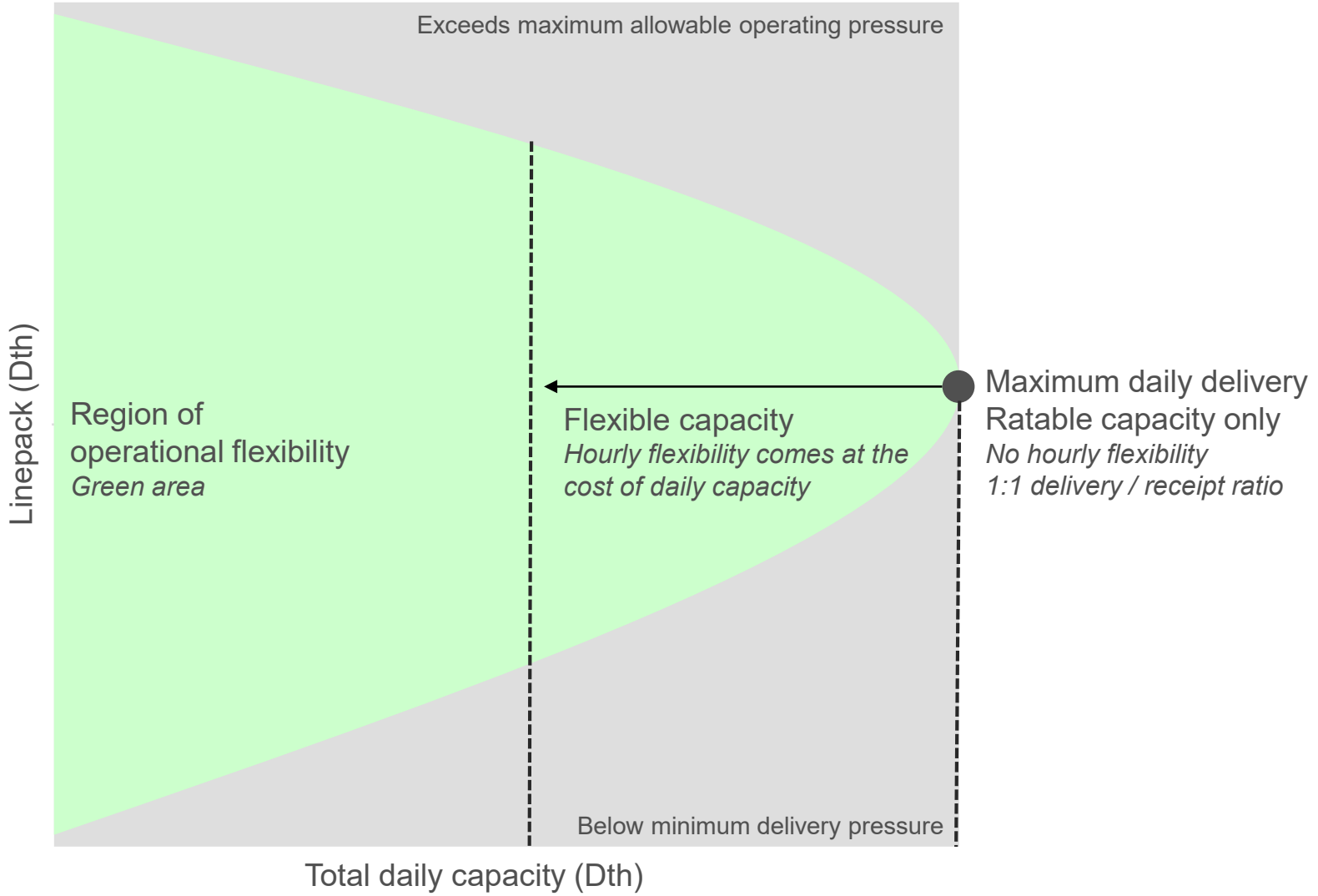
# Important to Ensure Adequate Pipeline Capacity

Hourly flexibility requires more infrastructure or less throughput & should be priced appropriately

Necessary to reduce the daily delivery quantity as the daily variation in linepack increases

Otherwise, linepack could fall outside of the region of operational flexibility

Natural gas infrastructure will be needed to accommodate the peak demand on flexible grids with increasing levels of variable renewable generation



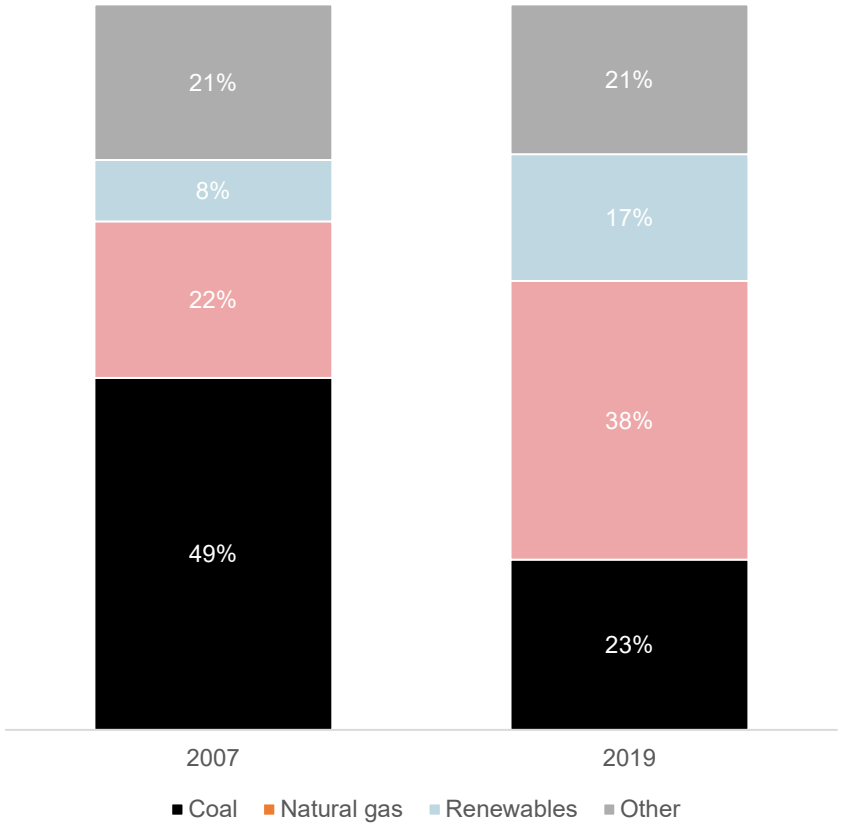
# LOW EMISSIONS

# U.S. $CO_2$ Emissions Declined Since 2007

Primarily due to converting coal power generation to natural gas generation

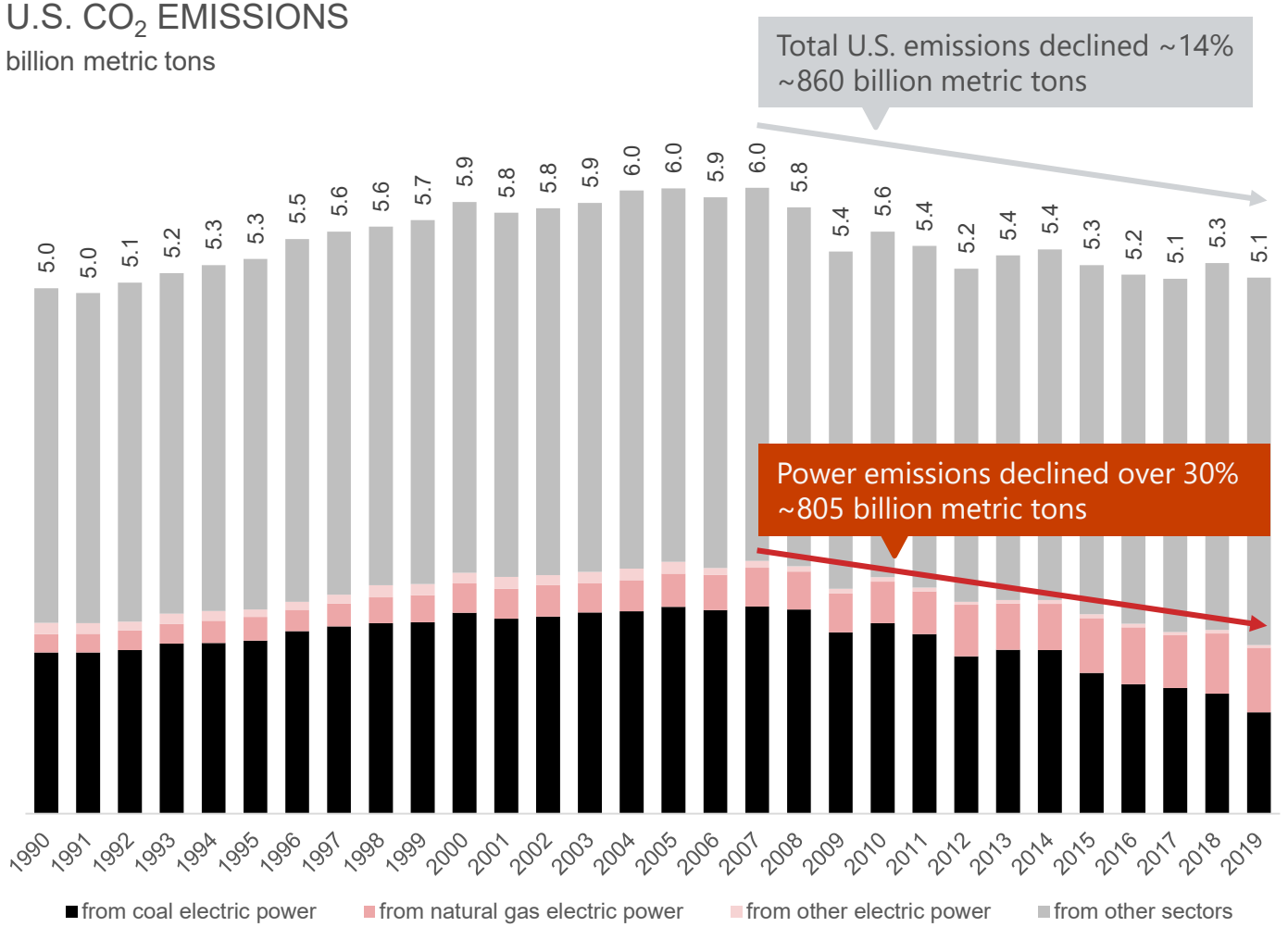
## U.S. ELECTRICITY GENERATION MIX

% of total generation




## U.S. $CO_2$ EMISSIONS

billion metric tons




Source: EIA Electricity Data Browser. Net generation.

# Replacing Coal Power is Critical to Reducing Global Emissions

Power sector contributes ~40% of energy-related $CO_2$ emissions globally & the U.S. can't solve it alone

## China & India expected to use coal to firm renewables
## Not ideal for meeting emission reduction goals

### Natural gas is **more efficient**

Burning natural gas is 25% more efficient than coal on average

### & **lower carbon** than coal

Coal releases ~75% to 85% more $CO_2$ per Btu than natural gas

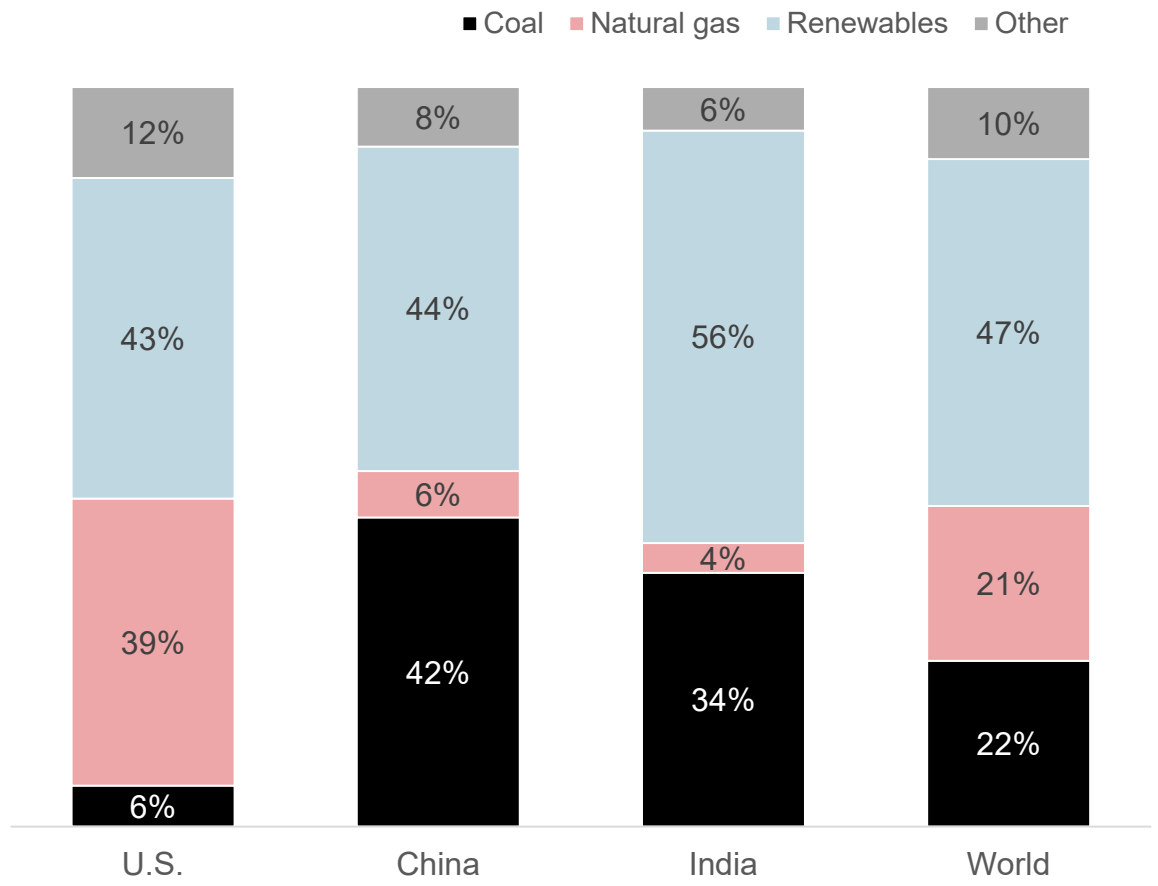
### In combination, this means

Natural gas fired generation emits ~60% less than coal-fired plants

"Coal-to-gas switching can provide quick wins for global emissions reductions. Theoretically, up to 1.2 Gt of $CO_2$ could be avoided using existing infrastructure…Doing so would bring down global power sector emissions by nearly 10%." – *IEA, World Energy Outlook 2019*

FORECASTED POWER GENERATION MIX IN 2040

% based on terawatt-hours




Source: U.S. Energy Information Agency, U.S. National Energy Technology Laboratory, International Energy Agency, World Energy Outlook, October 2020 (Stated Policies Scenario).
Note: Efficiency statistic based on heat rate (million Btu per kWh). Other in electric power generation mix includes nuclear & oil.

# Total Emissions Footprint Should be Considered

Scope 1, 2 & 3 needed to accurately frame the emissions influence across a given supply chain

- The total emissions footprint includes:
  - Scope 1: direct emissions from the “usage” of owned or controlled sources, including on-site combustion
  - Scope 2: indirect emissions from the “usage” of owned or controlled sources, such as emissions related to electricity purchased & used
  - Scope 3: all other indirect emissions that occur across the value chain up to & from production/consumption
- Consider a solar generation company, as an example:
  - Once installed, solar panels have low to no Scope 1 emissions from their everyday use generating power
  - However, meaningful Scope 3 emissions are generated from mining, raw material production, manufacturing, transporting & installing solar panels
  - Additional Scope 2 emissions from backstopping intermittent solar power include operating traditional power plants at lower efficiencies (ramping up/down) & from building battery storage

Important to look beyond Scope 1 when shaping policies around emissions — like a carbon tax — which create incentive mechanisms upstream & downstream across the full supply chain

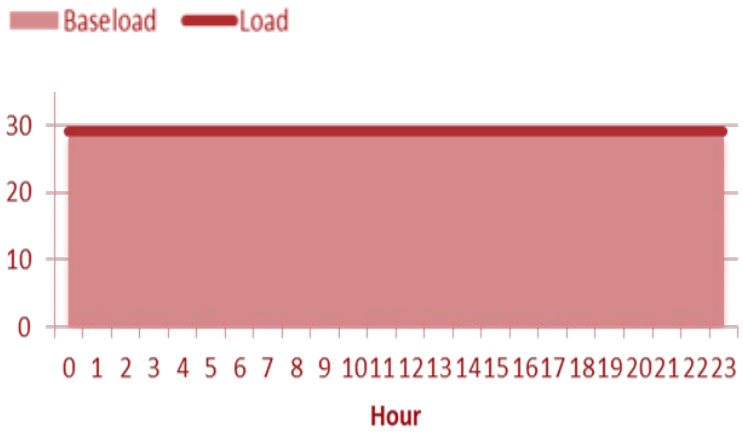
**EMISSIONS SCOPE FROM THE PERSPECTIVE OF A SOLAR GENERATION COMPANY:**

| Supply chain process<br>*Example activity* | Type of emission from activity | Energy consumed during activity |
|---|---|---|
| Raw materials acquisition<br>*Minerals & metals mining, petroleum extraction* | 3 | 2 |
| Materials manufacture<br>*Plastics, metals, semiconductors* | 3 | 2 |
| Product manufacture & delivery<br>*Final assembly, packaging, & shipping* | 3 | 2 |
| Product consumption<br>*Solar panels in use for power generation* | 1 | 2 |
| Final disposition<br>*Removal, transport, disposal* | 3 | 2 |
| Reuse – back to product consumption / Recycle – back to product manufacture | 3 \| 3 | 2 \| 2 |

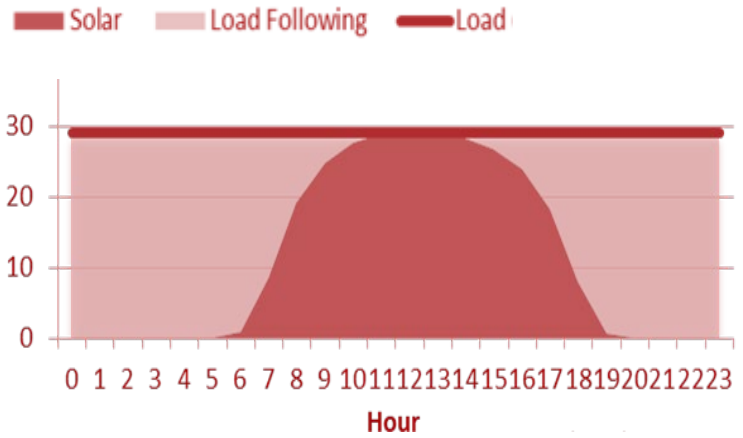
# Comparison of Greenfield Generation Alternatives

Illustrative 30 gigawatt load indicative of California

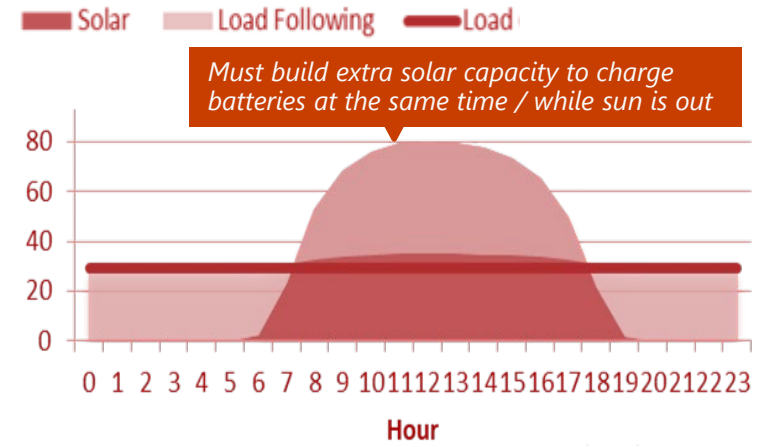
## NATURAL GAS COMBINED CYCLE




## SOLAR + NATURAL GAS PEAKER

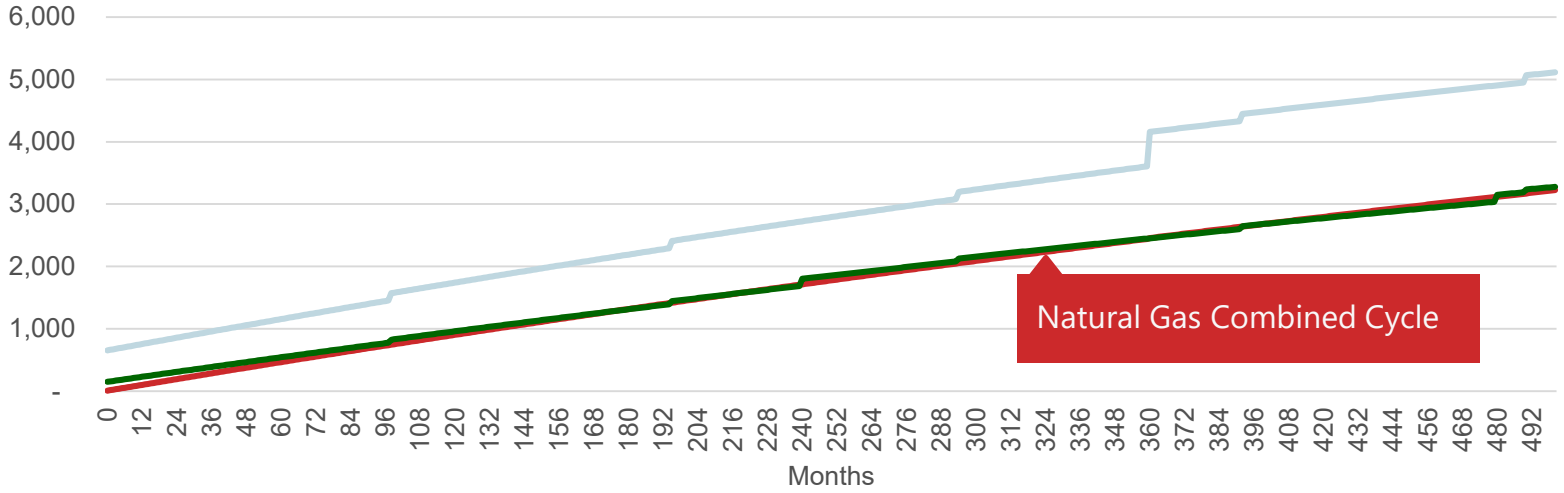



## SOLAR + LITHIUM BATTERY




## CUMULATIVE EMISSIONS OVER TIME *considering full cycle emissions & equipment replacement requirements*

$CO_{2e}$ emissions in million metric tons




**Solar + Lithium Battery**
*Meaningful Scope 3 emissions to construct facility, plus batteries replaced every 8 years & new solar panels every 30 years*

**Wind + Lithium Battery**
*Higher Scope 3 emissions to construct facility but lower daily emissions than natural gas combined cycle*

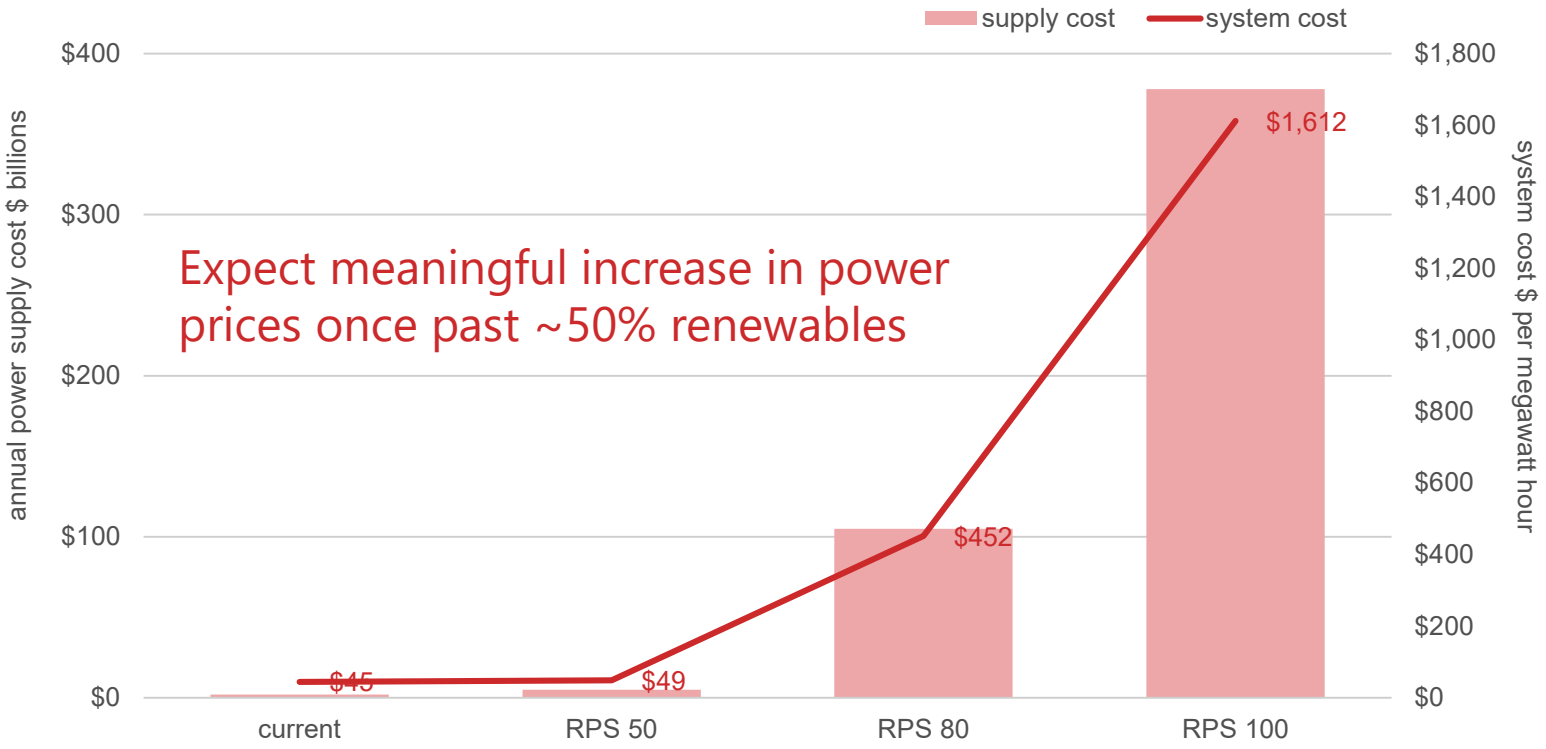
*Natural gas is competitive with renewables when factoring reliability into the assessment of full life cycle emissions*

Source: KM analysis (see Appendix for additional information).

# Considerations for Consumer Rates

While solar & wind costs have declined, total system cost becomes unmanageable at high levels of renewable penetration

CAISO POWER SUPPLY COST




"Wind and solar resources are not consistently available and controllable to serve the energy needs of all customers all the time on the whole energy system. For our system today, **the cost of integrating renewable energy is manageable up to about 50% to 60%** renewable penetration. At that point, however, the cost of integrating additional renewable energy begins to climb rapidly."

*Ben Fowke, Xcel Energy CEO*
*U.S. Senate Committee on Energy & Natural Resources on June 4, 2019*

- As the level of renewable penetration increases in each Renewable Portfolio Standard (RPS) scenario, intermittency in the power supply increases as well
- Such intermittency creates the need for a significant amount of incremental battery capacity to maintain reliability → rapidly drives up system costs
- During periods when renewable output is very high, the California energy system would need to generate substantial additional energy to charge a massive amount of battery capacity to ensure that load/demand is also served during periods when renewable output is relatively low

Source: February 2019 Clean Air Task Force analysis of CAISO data.

# RENEWABLE OPPORTUNITIES

*For natural gas infrastructure*

# Renewable Natural Gas (RNG) & Hydrogen Behave like Natural Gas

Fits nicely with our existing, expansive network of natural gas infrastructure

RNG is a pipeline-quality gas that is **interchangeable with conventional natural gas**

- Can be transported, stored & used in the same applications as natural gas



Hydrogen could be shipped on natural gas pipelines in 5% to 10% blends with **little to no modification**

- Depends on pipeline metallurgy, age & other operating parameters

**5-10%**

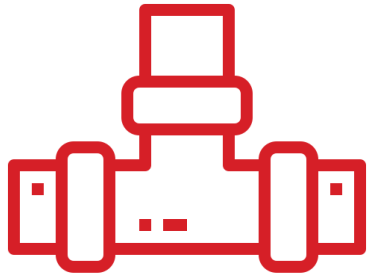
Hydrogen is **energy dense** & well suited to **long-distance transportation**

- On a volume basis, hydrogen is 1/3 as energy dense as natural gas and therefore may require ~3x as much capacity to transport the equivalent amount of energy

**~3x** infrastructure capacity

**Pipelines** can transport hydrogen **more efficiently** than transmission lines[(a)]

- Larger quantities
- 10-20x cheaper
- Avoids the electricity losses



Carbon-neutral energy sources will be important to limit global temperature rise while still supporting global economic growth

RNG & hydrogen can utilize much of the existing natural gas infrastructure network

a) Source: Becker, Meike. "All hydrogen roads lead to renewables (and through Rome?)" Sanford C. Bernstein & Co., LLC. September 3, 2020.

# Opportunity for Natural Gas Infrastructure

Renewable alternatives are small in scale today, but could grow to meet nearly 30% of current U.S. demand

## **RENEWABLE NATURAL GAS** (RNG)

Essentially a biogas: the gaseous product of the decomposition of organic matter, which has been processed to purity standards

Made from animal waste, crop residuals, food waste, landfills, etc.

*Potential challenges include aggregation across many small tracts of supply, requirement to process to meet pipeline quality specs & expensive to scale RNG production facilities*




## **HYDROGEN**

Grey to Blue Hydrogen is produced using fossil fuels as a feedstock via steam methane reformation with potential of using carbon capture & storage

Green Hydrogen is produced when renewable power is used in the electrolysis process

*Potential challenges include blending while maintaining pipeline specs, pipeline embrittlement issues & electrolyzers bear large capital cost*




*Similar to the way natural gas is used today:*

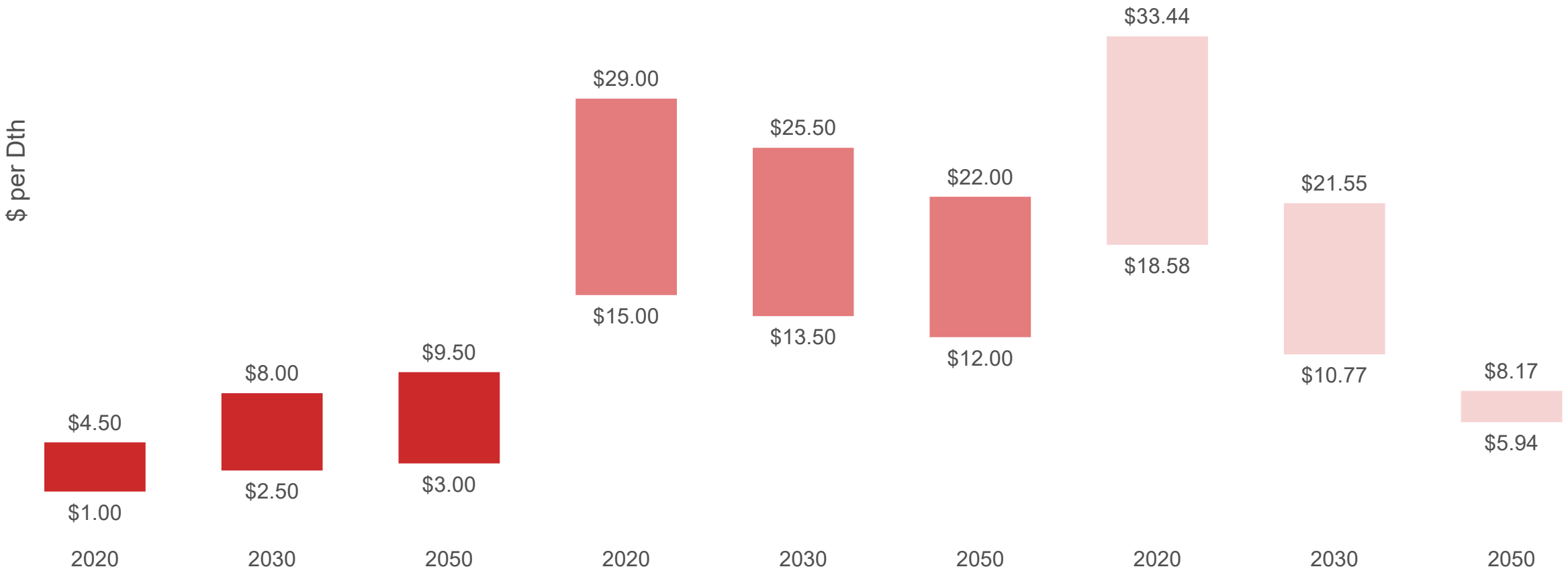
Both can be transported as a gas by pipelines, moved in liquid form by ships & stored in geologic caverns & depleted reserves

Could help decarbonize many sectors & applications: fuel for power & transport, heat for industry & buildings, feedstock for chemicals, etc.

Source: 2019 U.S. RNG supply estimated from EPA. 2050 U.S. RNG supply potential from NREL. "Energy Analysis - Biogas Potential in the United States." October 2013, 2020. 2019 U.S. hydrogen supply estimated from EIA. 2050 U.S. hydrogen supply potential from Hydrogen Council. "Hydrogen scaling up: A sustainable pathway for the global energy transition." November 2017.
Current U.S. natural gas demand based on 2020 estimate of 96.5 Bcfd (including exports) from WoodMackenzie Summer 2020 Long Term Outlook.

# Economics Expected to Improve for Renewable Alternatives

While production costs are uncompetitive with natural gas today, they are estimated to be more comparable by 2050




Source: IEA, KM analysis.

# Natural Gas Infrastructure is Required for Decarbonization

While reliably meeting energy demand

## Natural gas

- Critical for rapidly lowering emissions from the global power sector
- U.S. exports can help meet global energy demand
- Increased renewable penetration necessitates greater natural gas deliverability in order to effectively backstop
- Pipeline infrastructure & tailored pipeline services that meet peak hour requirements are key to ensuring grid reliability

## & renewable alternatives

- Leverages an extensive existing natural gas pipeline & storage infrastructure network, which can be:
  - inexpensively upgraded to accept hydrogen blends, or
  - repurposed to take a variety of low carbon fuels

## Will be essential to a clean, reliable, affordable energy future

# APPENDIX

# Challenges from Increasing Renewables in the Power Sector

## Creates opportunities for natural gas infrastructure

### FORECASTED RENEWABLE POWER GENERATION

% of total power generation by U.S. region

| | Southeast | Northeast | Great Lakes | Midwest | Other West | California | Texas |
|---|---|---|---|---|---|---|---|
| 2020 | 5% | 7% | 8% | 23% | 17% | 34% | 24% |
| 2021 | 5% | 7% | 11% | 28% | 17% | 37% | 30% |
| 2022 | 5% | 9% | 14% | 32% | 20% | 42% | 32% |
| 2023 | 6% | 12% | 15% | 32% | 22% | 44% | 31% |
| 2024 | 7% | 15% | 16% | 32% | 23% | 46% | 31% |
| 2025 | 7% | 17% | 16% | 32% | 24% | 48% | 30% |
| 2026 | 8% | 19% | 17% | 33% | 26% | 49% | 31% |
| 2027 | 9% | 21% | 17% | 34% | 27% | 49% | 33% |
| 2028 | 9% | 23% | 18% | 35% | 28% | 50% | 34% |
| 2029 | 10% | 25% | 18% | 36% | 29% | 50% | 35% |
| 2030 | 11% | 27% | 18% | 37% | 30% | 51% | 36% |
| 2031 | 11% | 28% | 18% | 37% | 30% | 51% | 36% |
| 2032 | 12% | 29% | 18% | 37% | 30% | 51% | 35% |
| 2033 | 12% | 29% | 18% | 37% | 30% | 51% | 34% |
| 2034 | 13% | 30% | 18% | 36% | 31% | 51% | 34% |
| 2035 | 13% | 31% | 18% | 36% | 31% | 51% | 33% |
| 2036 | 14% | 32% | 19% | 39% | 33% | 54% | 34% |
| 2037 | 14% | 33% | 20% | 41% | 34% | 57% | 35% |
| 2038 | 15% | 34% | 21% | 43% | 36% | 59% | 36% |
| 2039 | 16% | 34% | 22% | 45% | 38% | 61% | 37% |
| 2040 | 16% | 35% | 24% | 47% | 39% | 64% | 38% |
| 2041 | 18% | 36% | 24% | 49% | 40% | 65% | 40% |
| 2042 | 21% | 36% | 25% | 50% | 41% | 65% | 41% |
| 2043 | 23% | 37% | 26% | 52% | 41% | 66% | 42% |
| 2044 | 25% | 37% | 26% | 53% | 42% | 67% | 44% |
| 2045 | 27% | 38% | 27% | 54% | 43% | 68% | 45% |
| 2046 | 30% | 38% | 28% | 56% | 43% | 69% | 46% |
| 2047 | 32% | 38% | 28% | 57% | 43% | 70% | 47% |
| 2048 | 34% | 39% | 29% | 58% | 42% | 70% | 48% |
| 2049 | 36% | 39% | 30% | 59% | 43% | 71% | 49% |
| 2050 | 38% | 39% | 30% | 61% | 43% | 71% | 50% |

| **Renewable** generation % | **Implication** for power grid |
|---|---|
| **0-10%** | Minimal impacts |
| **11-20%** | Requires flexible / responsive generation sources in power mix<br>Additional need for natural gas-fired peaker plants |
| **21-33%** | Natural gas-fired peaker plants ramp frequently to meet fluctuating demand<br>Start to see electricity price increasing |
| **34%+** | Significant load following issues – ramping up & down creates additional challenges for infrastructure<br>Potential reliability issues given renewable intermittency<br>Potential for brown / blackouts without effective energy storage<br>More natural gas pipeline infrastructure needed to handle the rapid changes in demand unmet by renewables |

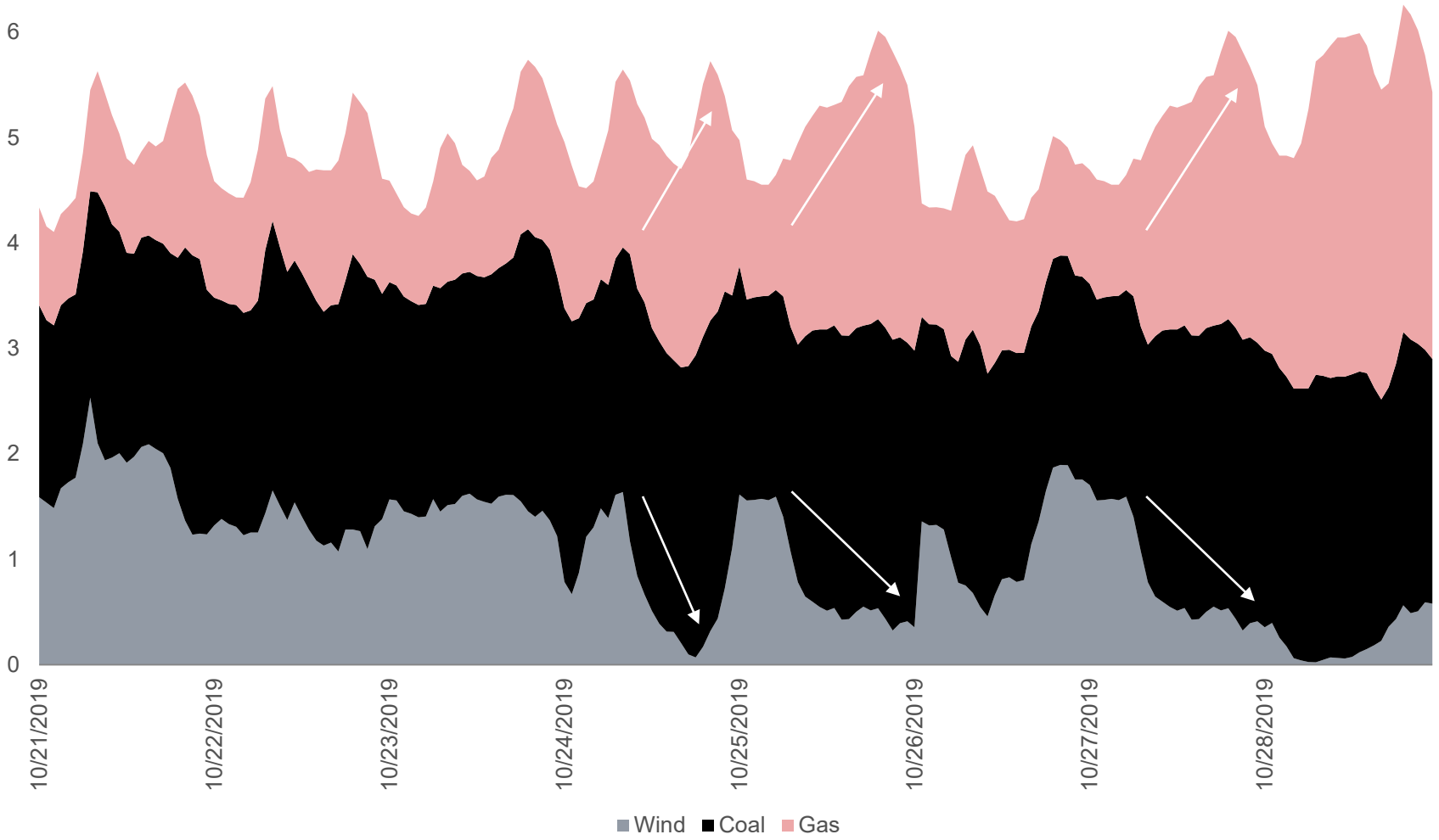
Source: ICF International Renewable Penetration Forecast, July 2020.

# Natural Gas Steps In when Renewables Drop Out

## Case study – Front Range of Colorado

XCEL COLORADO POWER GENERATION BY SOURCE

Gigawatts




Colorado's wind generation is backstopped by natural gas & coal

During a winter storm, wind generation decreased at the same time that power demand increased

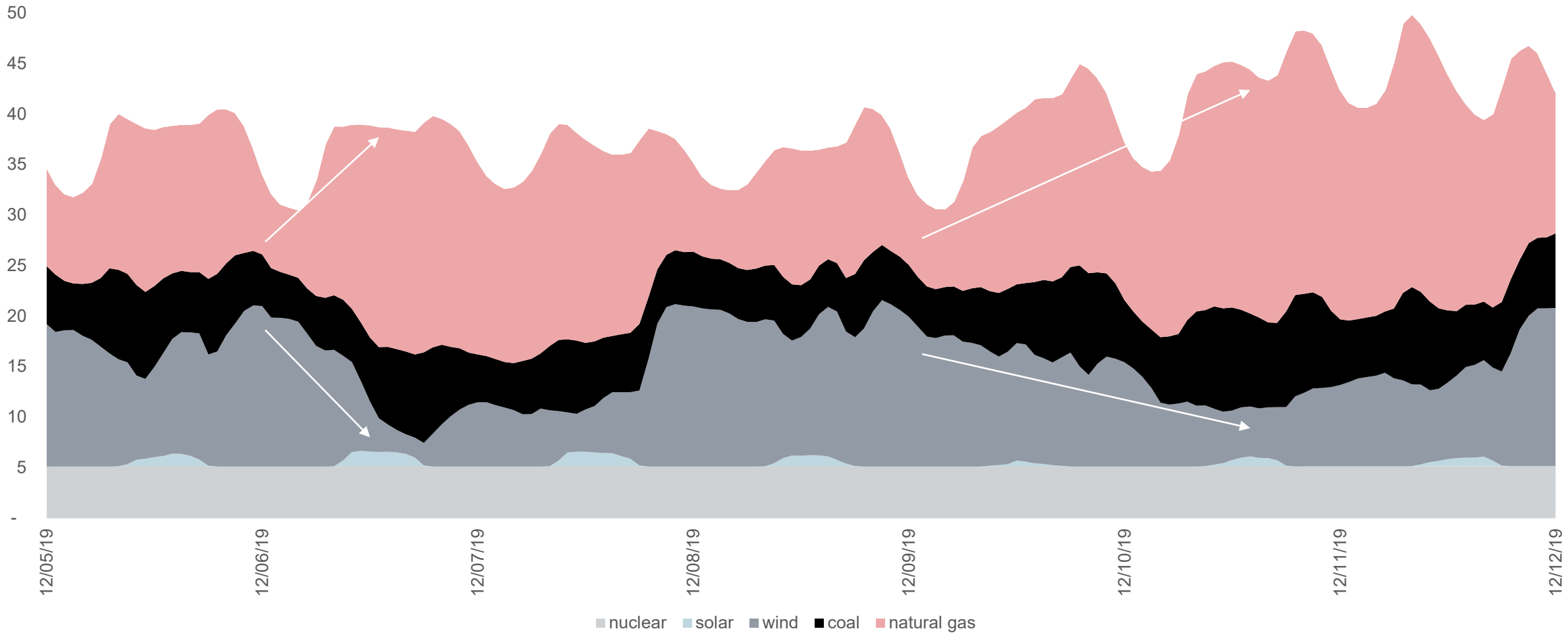
Fortunately, Colorado was able to dispatch natural gas & coal-fired energy to meet the higher demand without incurring reliability issues

Source: U.S. EIA Hourly Electric Grid Monitor.

# Natural Gas Steps In when Renewables Drop Out

## Case study – Texas

TEXAS POWER GENERATION BY SOURCE
Gigawatts




Source: U.S. EIA Hourly Electric Grid Monitor.

# Comparison of Greenfield Generation Alternatives

## Key assumptions & inputs for illustrative 30 gigawatt hours system

| Greenfield generation facility | Construction CAPEX $ billions | Scope 1 & 2 MMT $CO_{2e}$ per day | Scope 3 MMT $CO_{2e}$ to construct facility |
|---|---|---|---|
| | Calculated by applying Lazard's Levelized Cost of Energy v12 & Levelized Cost of Storage v4 to the capacity needed to meet the indicative load | Calculated by applying emissions from the following sources to the capacity needed to meet the indicative load. Sources include: (i) NREL Life Cycle Greenhouse Gas Emissions from Solar Photovoltaics, (ii) NREL Wind LCA Harmonization, (iii) IVL The Life Cycle Energy Consumption and GHG from Lithium Batteries. | |
| Natural Gas Combined Cycle | $49 | 0.26 | 10 |
| Solar + Natural Gas Peaker | $158 | 0.34 | 197 |
| Wind + Natural Gas Peaker | $182 | 0.27 | 75 |
| Solar + Lithium Battery<br>Grid-connected for backup | $518 | 0.30 | 657 |
| Wind + Lithium Battery<br>Grid-connected for backup | $325 | 0.23 | 141 |

| Cumulative emissions graph: | Slope of the line | Y-intercept | Jumps in the line |
|---|---|---|---|
| Greenfield generation facility | Scope 1 & 2 MMT $CO_{2e}$ per day | Scope 3 MMT $CO_{2e}$ to construct facility | Assumed replacement requirements |
| Natural Gas Combined Cycle | 0.26 | 10 | None over period shown |
| Solar + Lithium Battery<br>Grid-connected for backup | 0.30 | 657 | Solar replacement every 30 years<br>Battery replacement every 8 years |
| Wind + Lithium Battery<br>Grid-connected for backup | 0.23 | 141 | Wind replacement every 20 years<br>Battery replacement every 8 years |

Source: KM Analysis using data from EIA, Lazard, NREL and North American Electric Reliability Corporation (NERC).
Note: Values reflect empirical seasonal and hourly variation in load and generation and average NERC grid reliability.