KINDER MORGAN

NSPE-NM™ NEW MEXICO SOCIETY OF PROFESSIONAL ENGINEERS

Natural Gas Role in the Clean Energy Future

Will W. Brown, P.E.
Vice President, Commercial
West Region

Delivering Energy to Improve Lives and Create a Better World

Cautionary Language
Regarding Forward-Looking Statements

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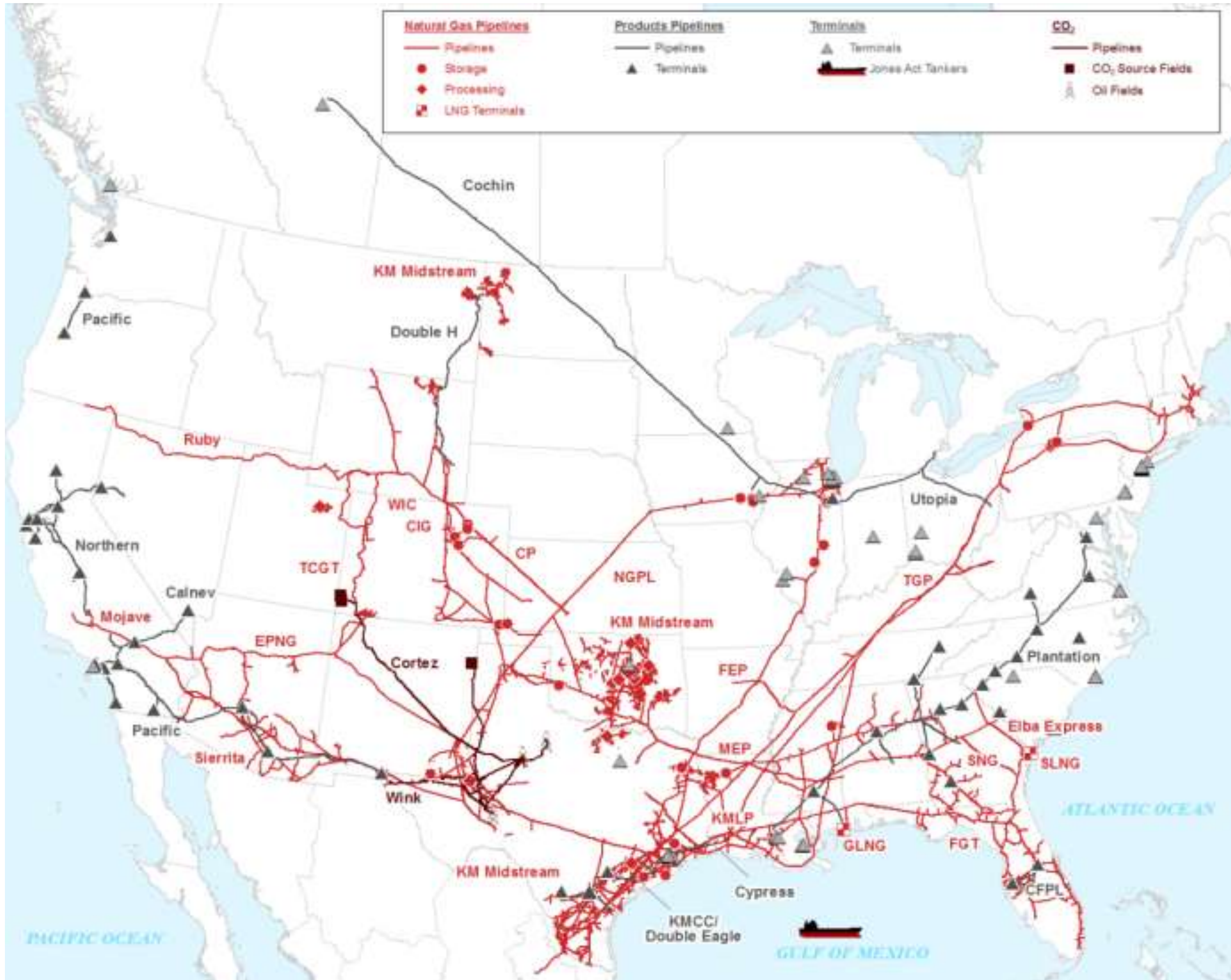
Agenda

- Overview
  - Natural Gas Industry
  - Kinder Morgan
- North American Natural Gas Macroeconomics
- Benefits of Natural Gas Infrastructure
  - Operational, Environmental, Economic
  - Case Studies
- Summary

The Natural Gas Industry (Continued)

Kinder Morgan Asset Map

- Largest natural gas network in North America
- Largest independent transporter of petroleum products in North America
- Largest transporter of CO_2 in North America
- Largest independent terminal operator in North America



North American Natural Gas Macroeconomic Overview

World is Growing by ~ 1 Billion People by 2030

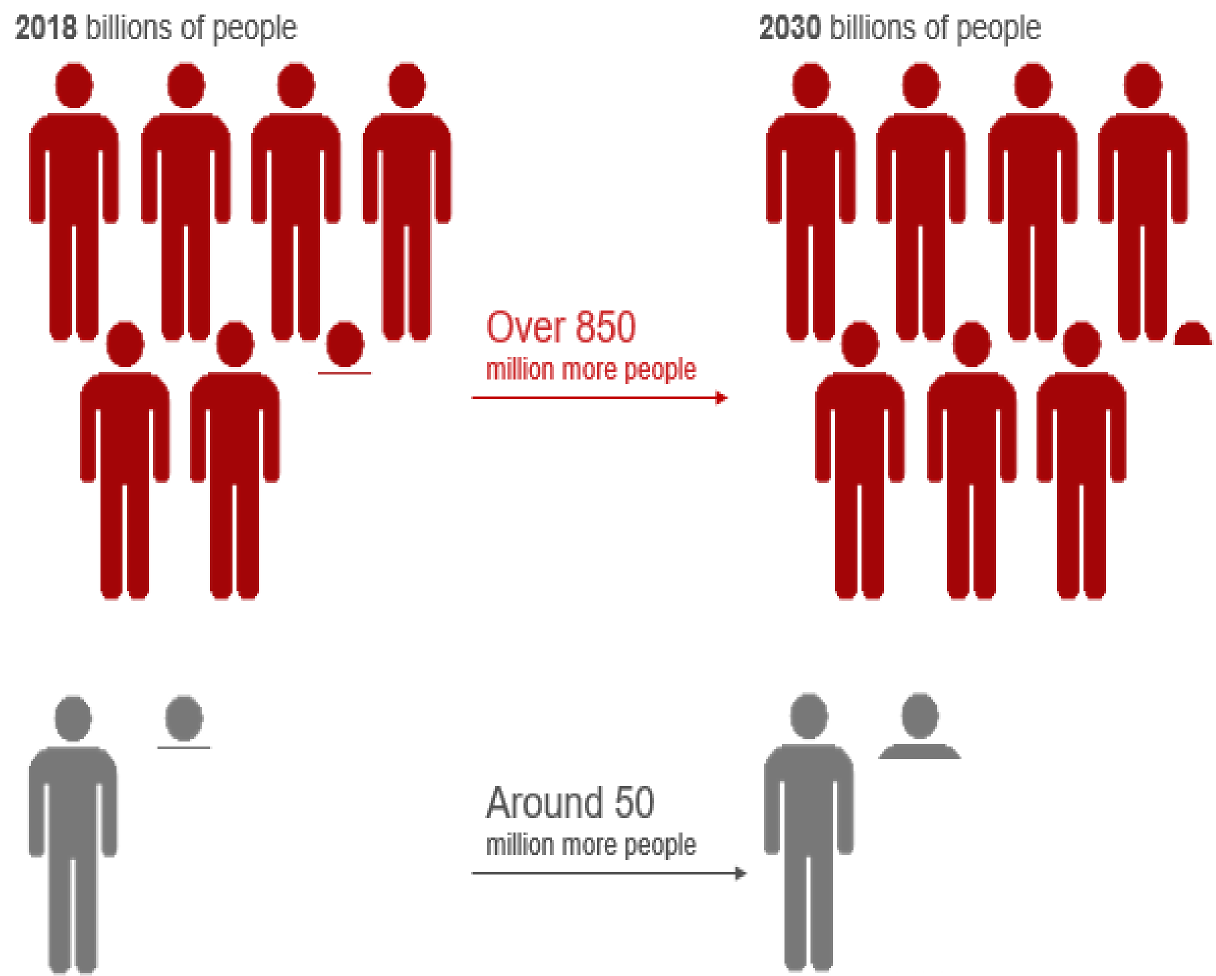
Over 90% of population growth occurs in developing countries

Non-OECD: ~6.3 BILLION

Over 80% of people
live in developing economies
such as India, China, Sub-Saharan Africa,
Indonesia, Pakistan, Brazil, etc.

OECD: ~1.3 BILLION

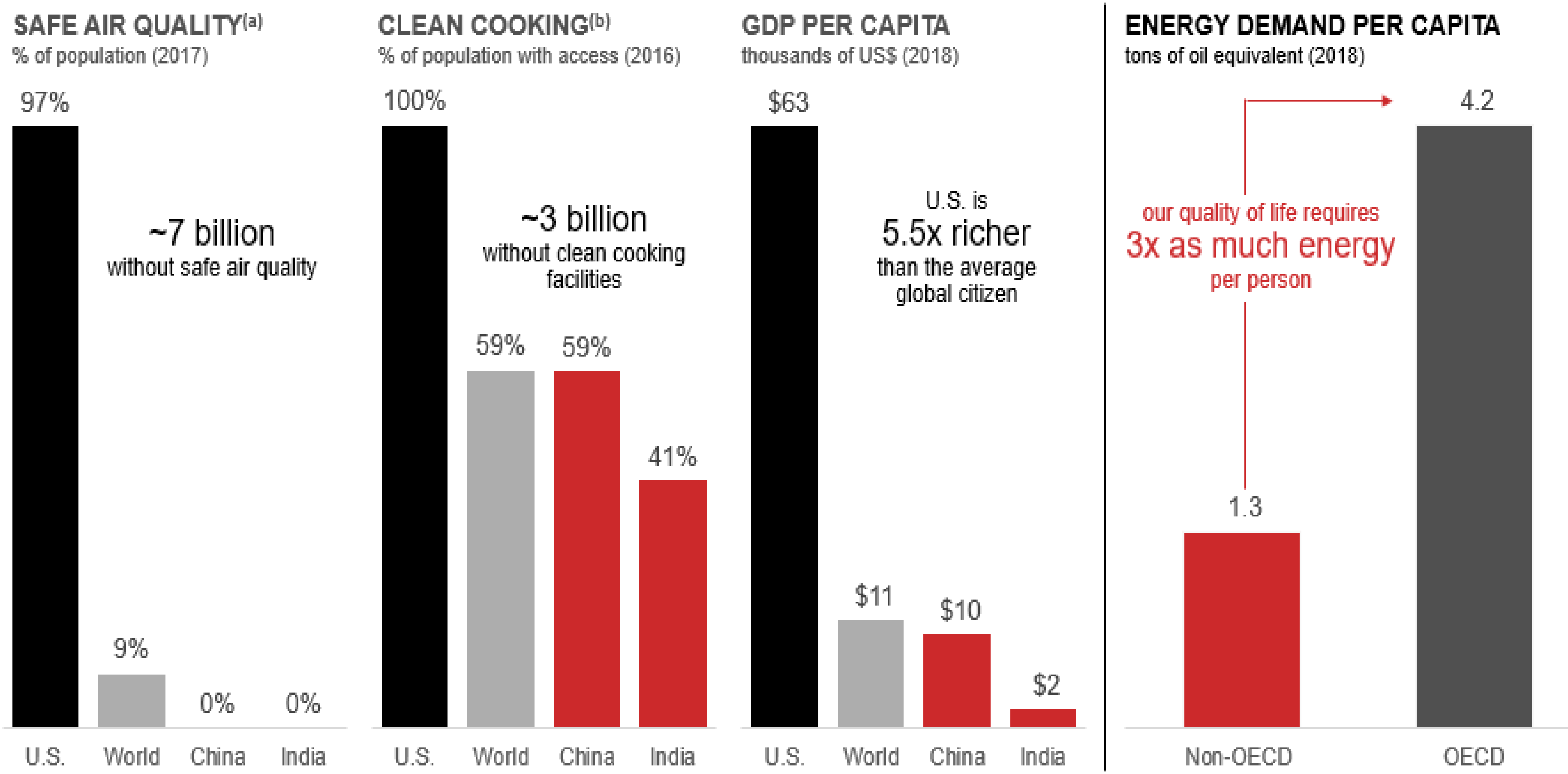
Less than 20% of people
live in advanced economies
such as U.S., Japan, European Union,
South Korea, Canada, Australia, etc.



Source: International Energy Agency, World Energy Outlook, November 2019 (Stated Policies Scenario)
Note: Organization for Economic Co-operation and Development (OECD) promotes global policies that foster prosperity, equality, opportunity and well-being. 36 member countries represent ~80% of world trade and investment.

Many People Still Lack Basic Needs & Technologies

Improving quality of life requires more energy

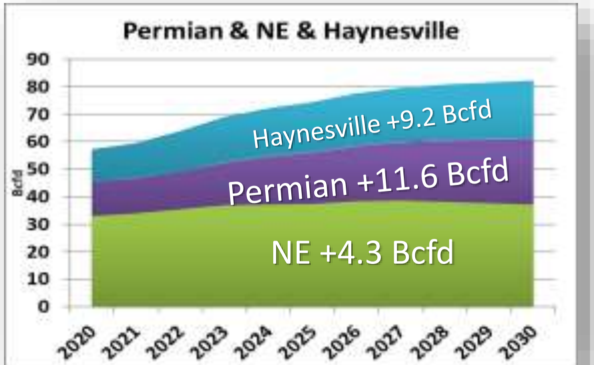


Source: World Bank, International Telecommunication Union, World Health Organization, International Energy Agency, World Energy Outlook, November 2019 (Stated Policies Scenario)

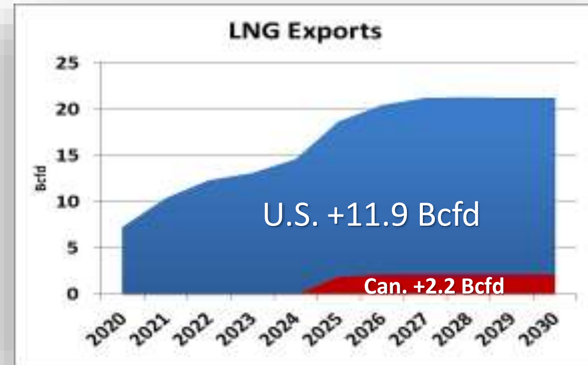
a) Per the World Health Organization's air quality guideline value of 10 micrograms per m^3 for ambient concentrations of particulate matter smaller than 2.5 µm ($PM_{2.5}$). These are the lowest levels at which total, cardiopulmonary and lung cancer mortality have been shown to increase with over 95% confidence in response to long term exposure to $PM_{2.5}$. In some areas, combustion of wood and other biomass fuels can be an important source.

b) Percent primarily using clean cooking fuels and technologies. The use of solid fuels and kerosene in households is associated with increased mortality from pneumonia and other acute lower respiratory diseases among children, as well as increased mortality from chronic obstructive pulmonary disease, cerebrovascular and ischemic heart diseases, and lung cancer among adults.

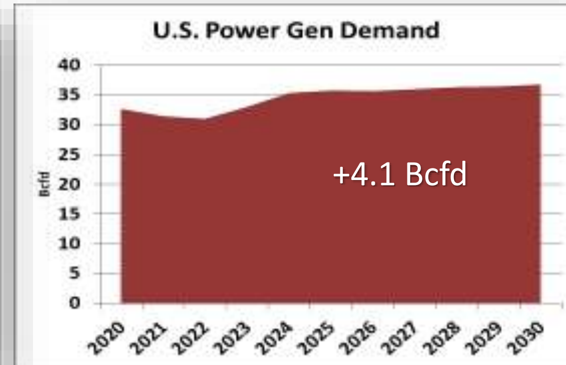
Key Trends Through 2030



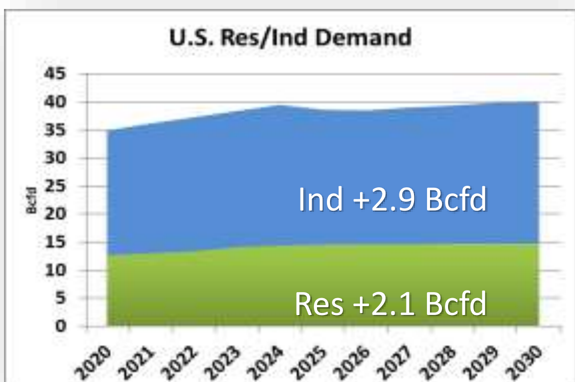
Continued supply increases



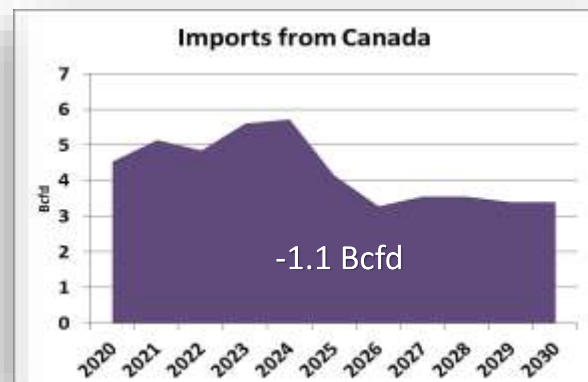
North America is a net exporter



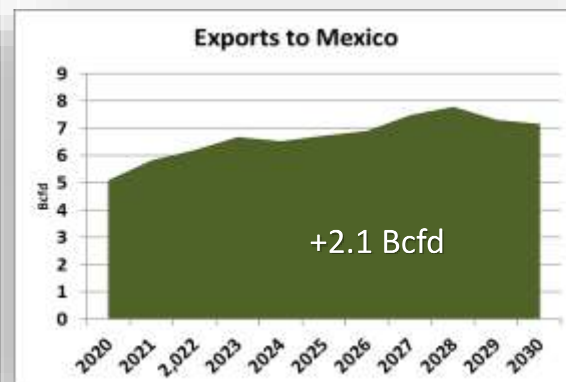
More Gas-fired generation



Residential & Industrial growth



Flat Canadian Exports to U.S.

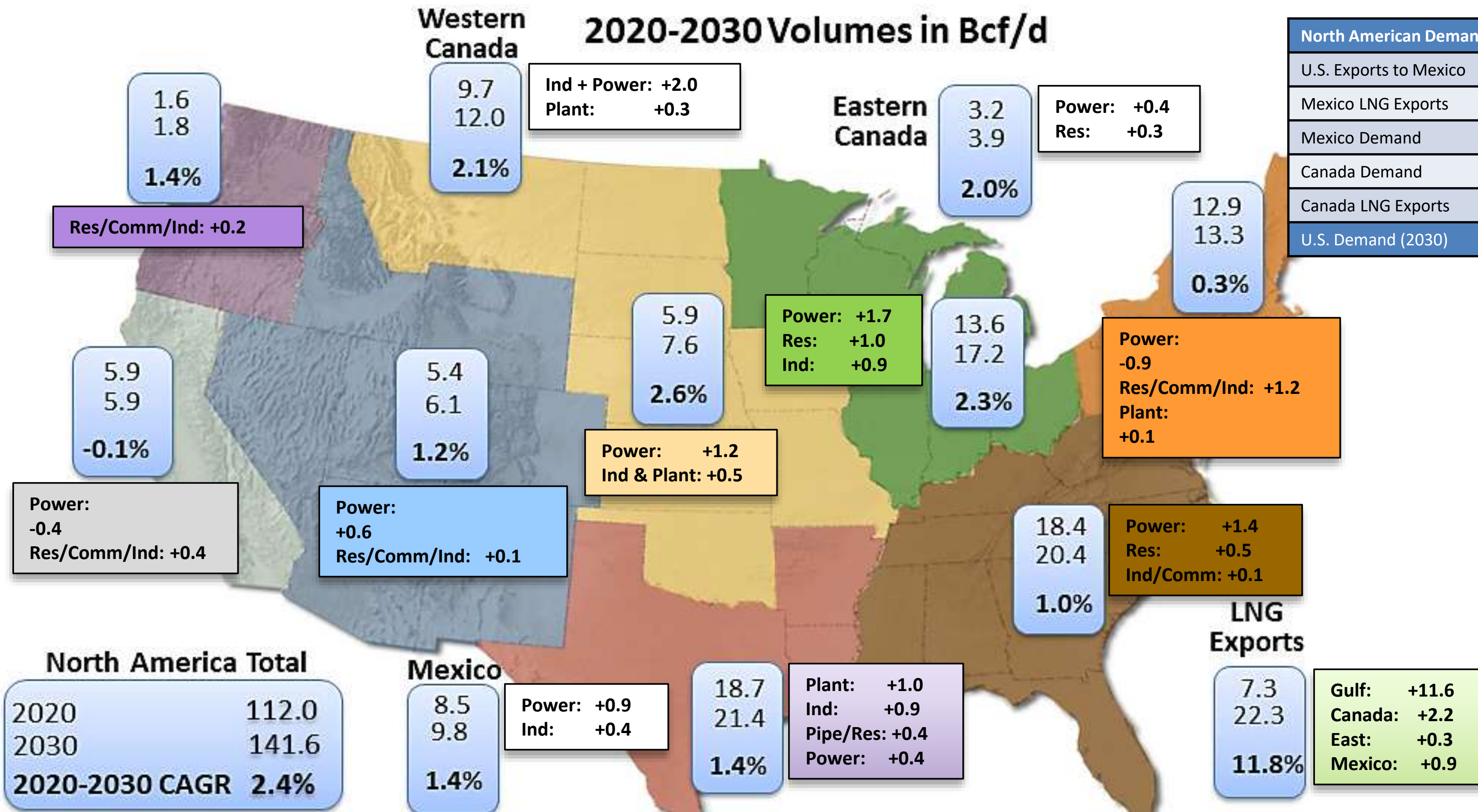


More U.S. Exports to Mexico

Source: ICF International and Kinder Morgan Analysis

Gas Demand

North American Demand	141.6
U.S. Exports to Mexico	+7.2
Mexico LNG Exports	-0.9
Mexico Demand	-9.8
Canada Demand	-15.9
Canada LNG Exports	-2.2
U.S. Demand (2030)	120.0



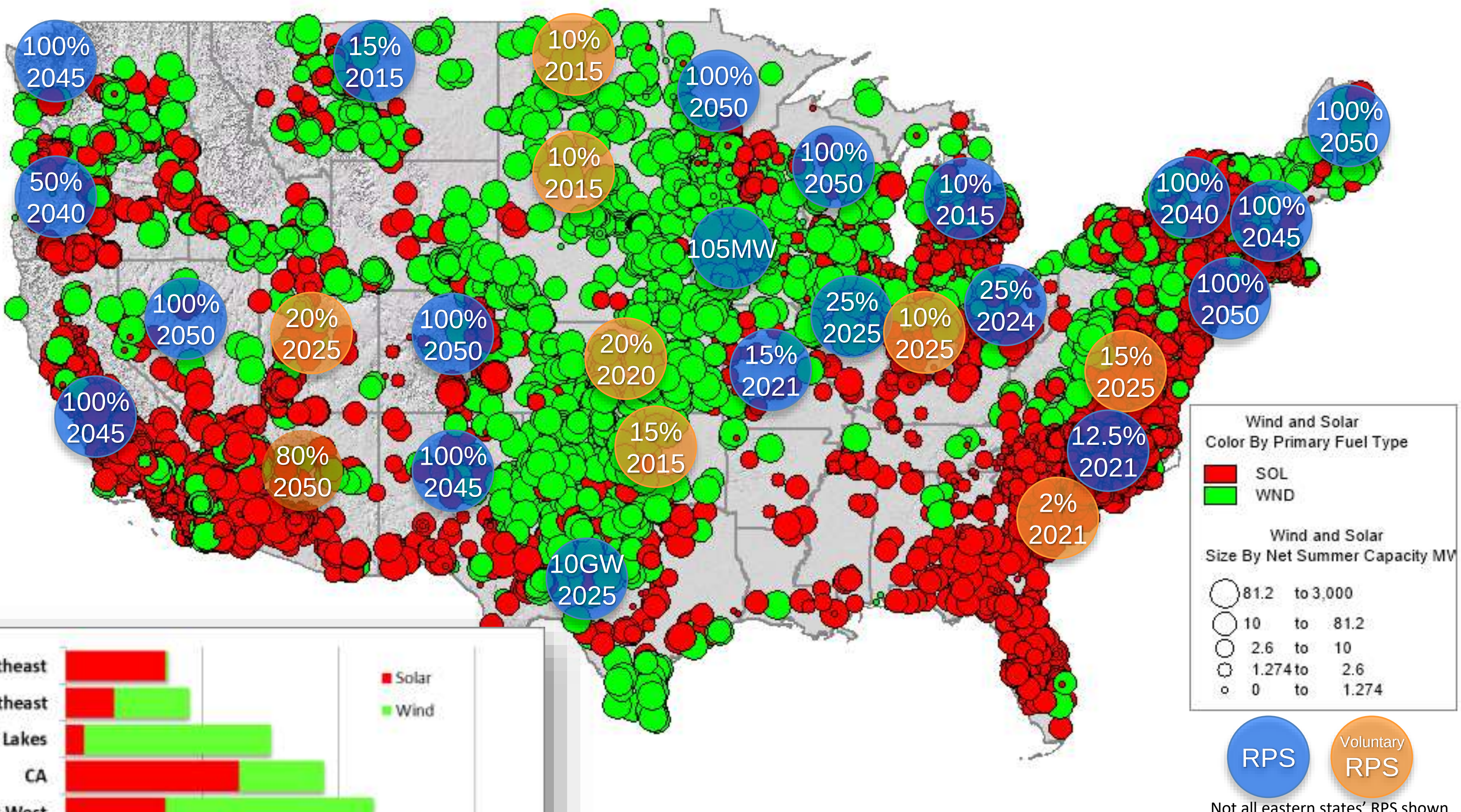
Including Exports

Benefits of Natural Gas Infrastructure

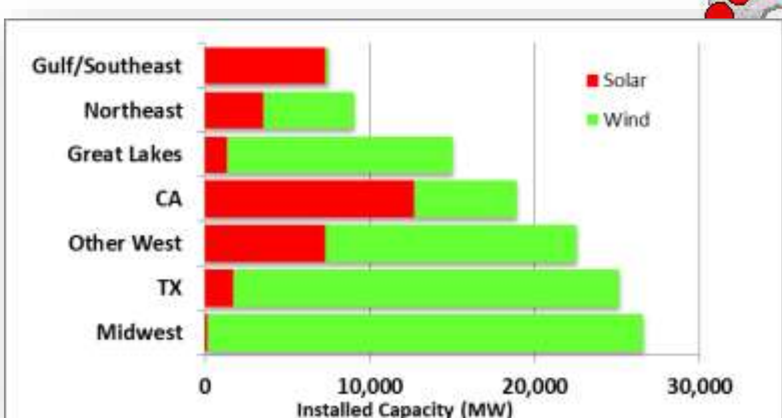
Delivering Energy to Improve Lives and Create a Better World

- Operational Benefits
- Environmental Benefits
- Economic Benefits

Wind and Solar Generating Capacity

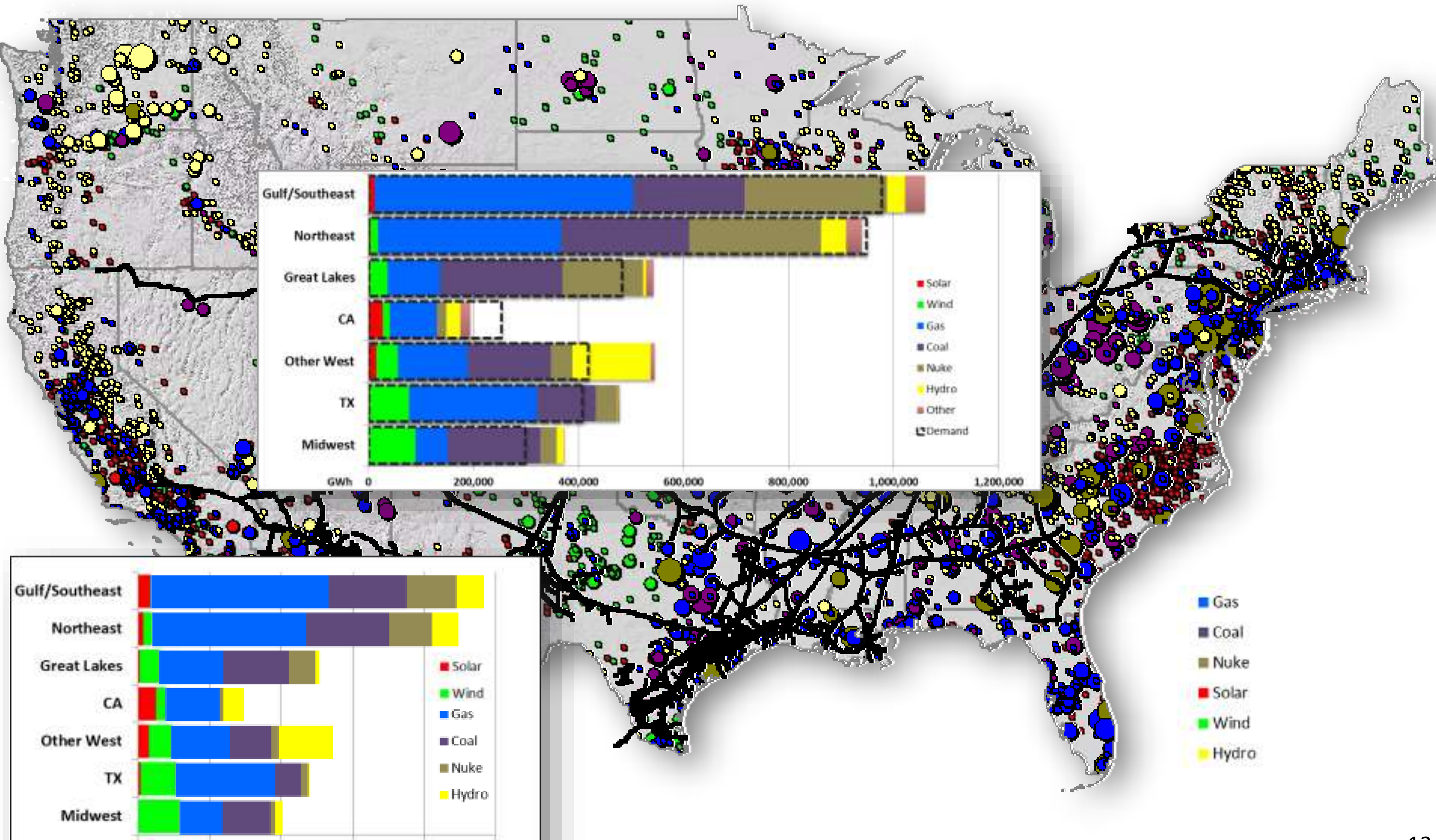


Not all eastern states' RPS shown



Source: ABB Velocity Suite, National Conference of State Legislators

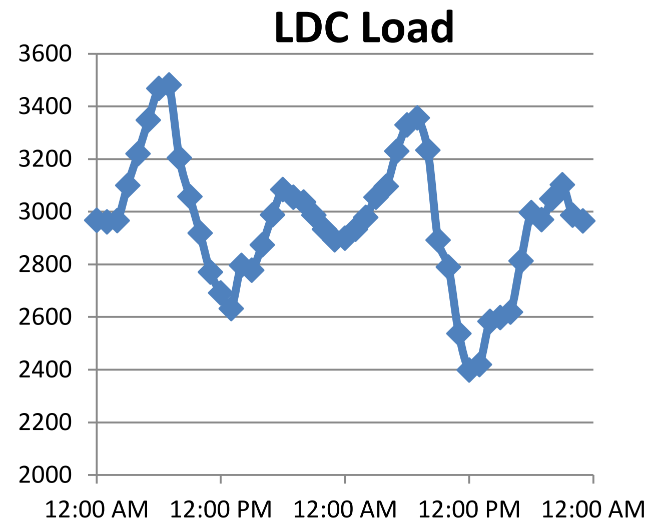
KMI Natural Gas System Amid Traditional and Variable Generations Resources



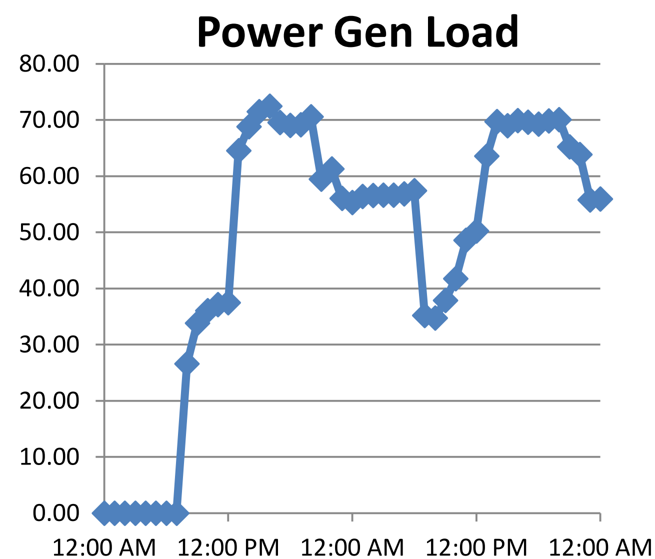
Source: ABB Velocity Suite, EIA

Kinder Morgan Pipelines have been Managing Demand Variation for Decades

- Local Distribution Companies (LDC)
  - Primarily space heating: homes, businesses, public
  - Hourly usage typically follows a consistent pattern
  - Daily usage dependent largely on ambient temperature

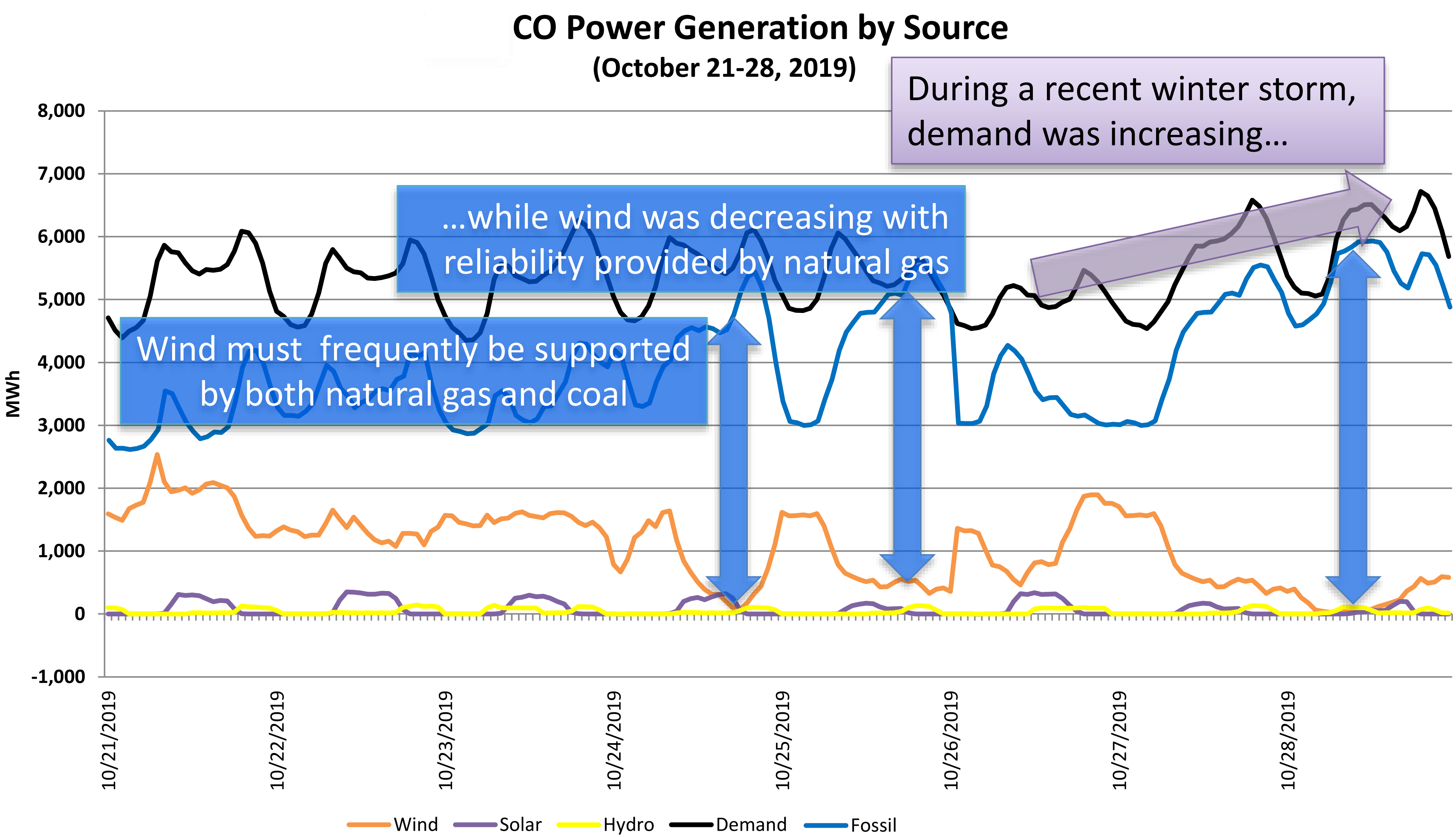


- Intermittent renewable-induced demand variation
  - Can exacerbate or mitigate historical demand profiles
  - Reflected primarily through electric generation load



- Electric generation share increasing
  - Nearly instantaneous ramps, up and down
  - Hourly usage pattern can vary significantly on the day, e.g., unanticipated loss of coal or nuclear generation
  - Daily usage dependent on ambient conditions and increasingly "external" factors

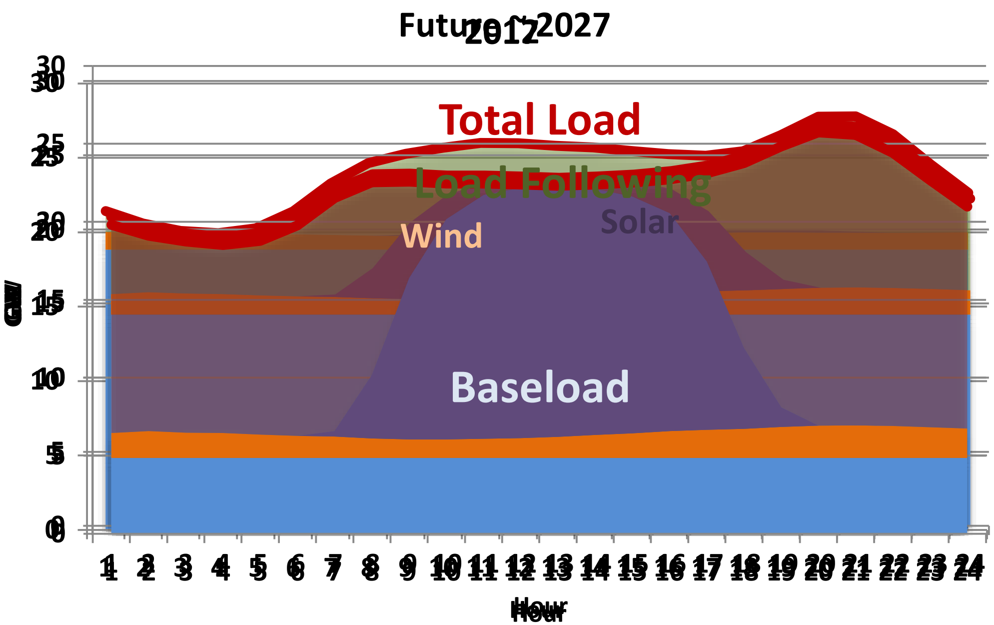
Case Study – Front Range of Colorado

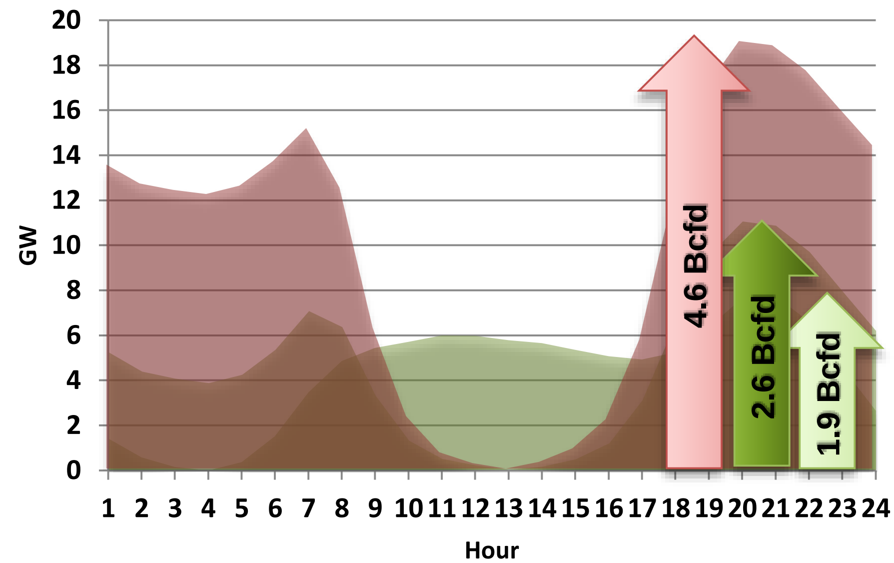


Source: EIA Real-time grid data

Natural Gas Complements Renewable Growth

As renewable generation increases, pipeline deliverability becomes increasingly important to natural gas-fired generation for load following





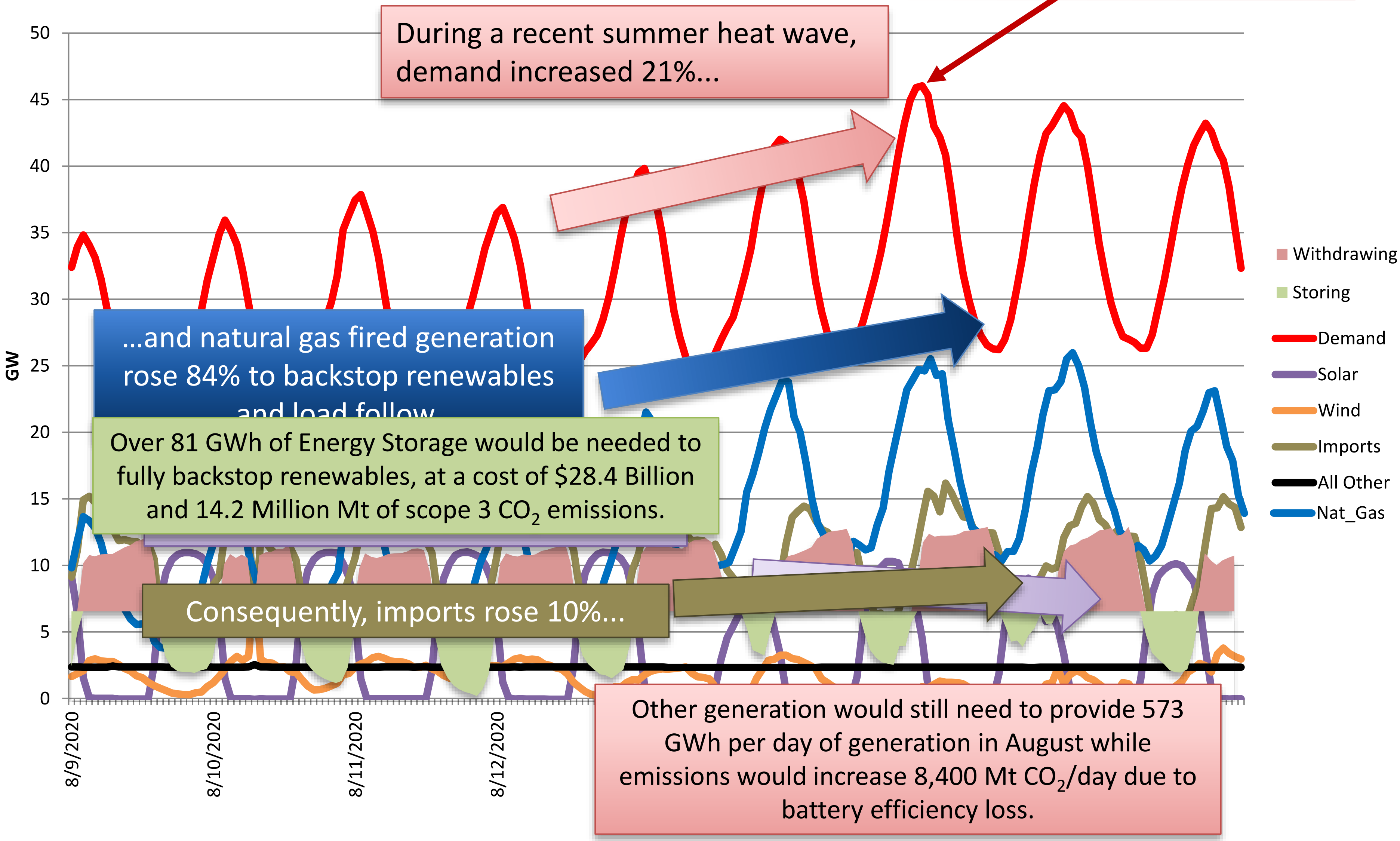
Reaching levels of renewable penetration > 50% requires excess renewable capacity, large transmission builds, AND significant energy storage capacity

Higher deliverability requires more capacity reservation (No-Notice, Hourly Services), more reliance on pipeline linepack, and/or market area storage

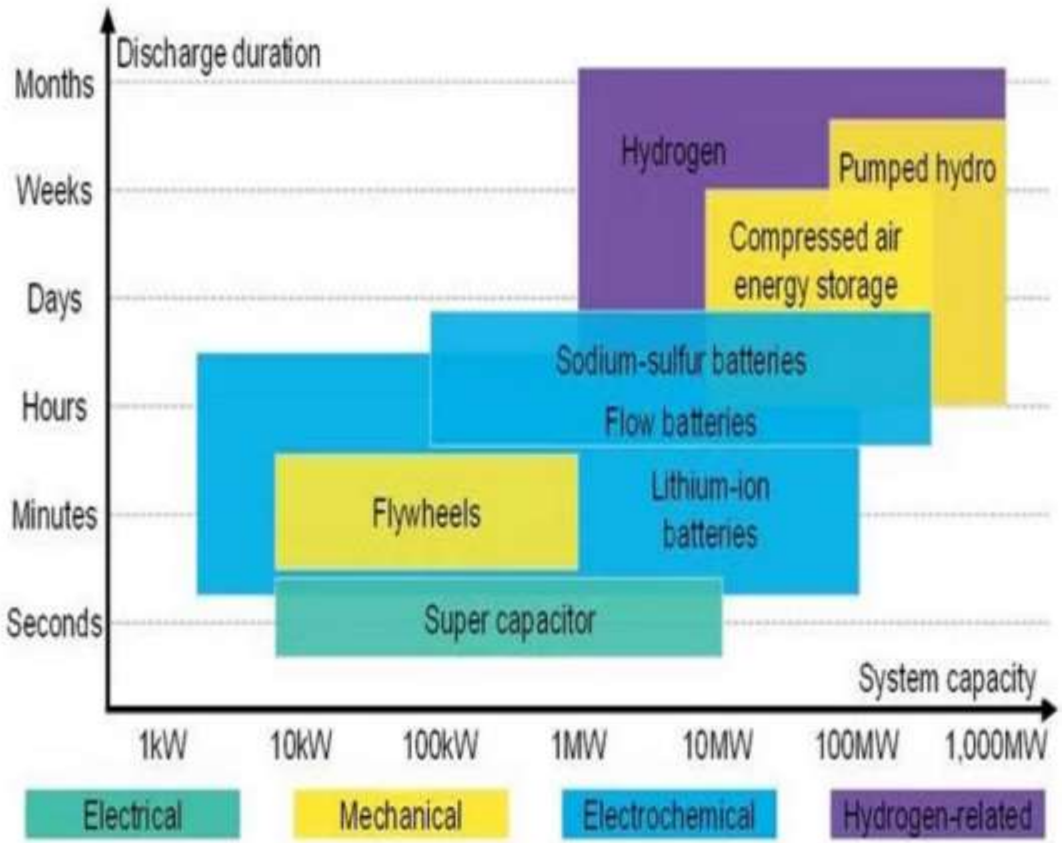
Sources: CAISO; KM analysis

Case Study – CAISO

Aug. 14, 2020 demand was 845 GWh, peaking at 46 GW at 6:00 PM, this was 91% of CAISO's highest demand experienced on Sept. 1, 2017 (932 GWh, with a peak hour at 5:00 PM of 50 GW).



Size and Discharge Duration by Energy Storage Technology



Source: Bloomberg New Energy Finance. Note: system capacities and discharge durations are based on general use, rather than technical limitations.

Cost are improving for battery technologies to penetrate the area of bulk power management applications for utility-scale operations, such as renewable backstopping and firming.

Battery technologies are currently suited for smaller duration such as, power smoothing (i.e VAR and frequency support), power quality, and overall grid support

Natural Gas Offers A Ready-Made Storage Solution

Underground storage functions as a large capacity, highly effective battery today

PROVIDING A BETTER BATTERY:

Incredibly large capacity (enough for days, weeks & months)

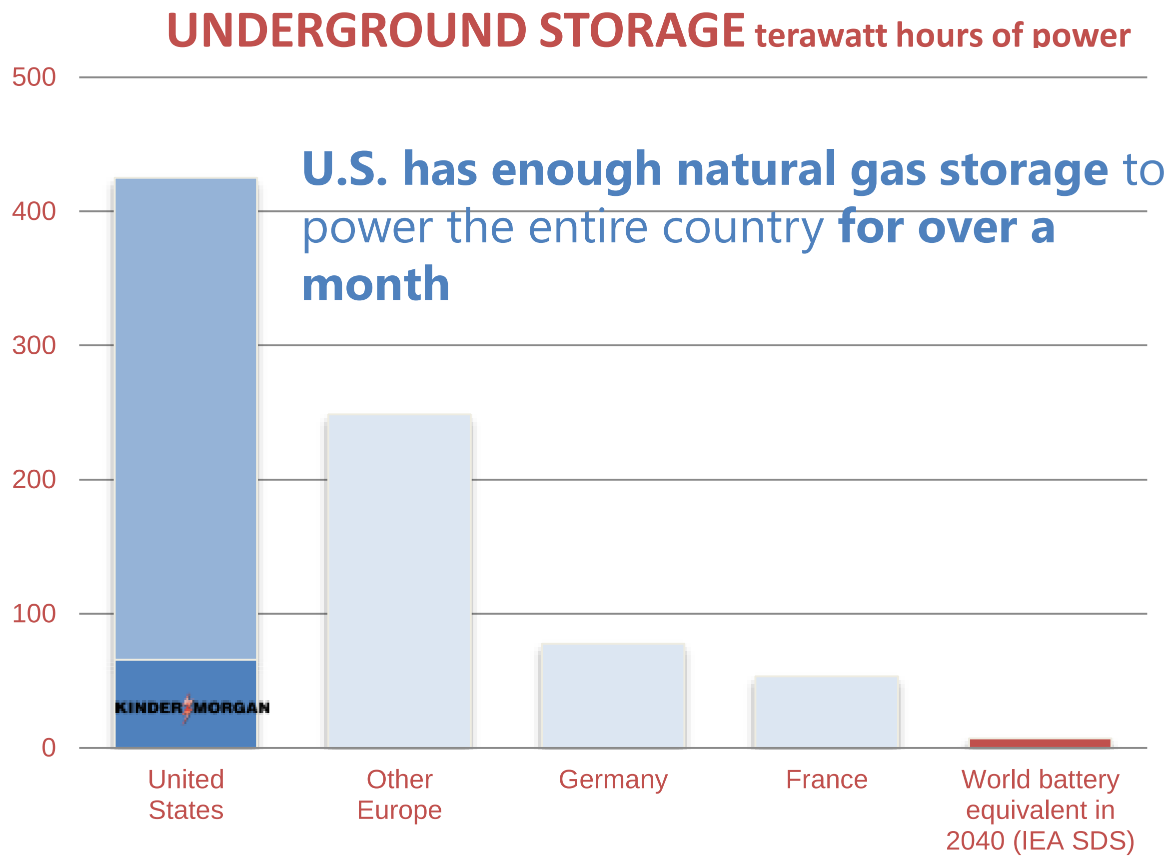
Reliably dispatchable (over short & long durations)

Uses existing infrastructure

Competitively priced

Enhanced by pipeline management

Does not require technological advancement



Source: KM analysis, IEA World Energy Outlook, October 2020.
Note: Energy storage converted into power equivalent using assumed 34% efficiency rate of a natural gas peaker plant.

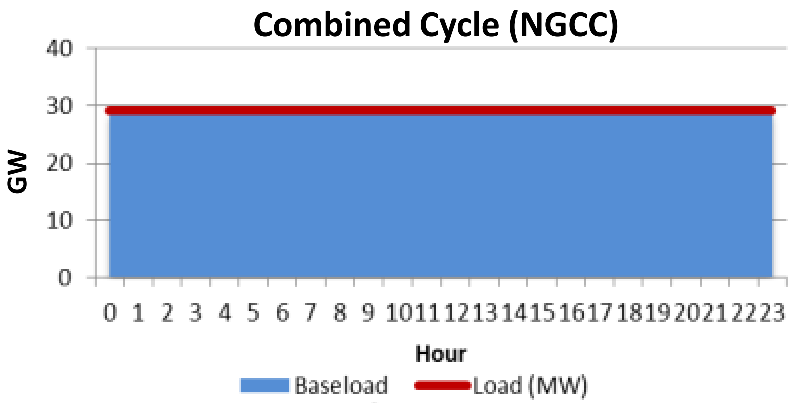
Life Cycle Assessment of GHG Emissions

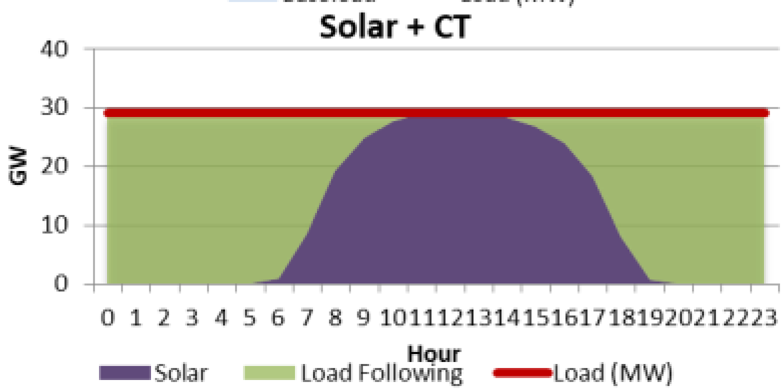
Total Emissions Footprint = **SCOPE 1** ‘Direct’ + **SCOPE 2** ‘Indirect’ + **SCOPE 3** ‘Up/Downstream Effects’

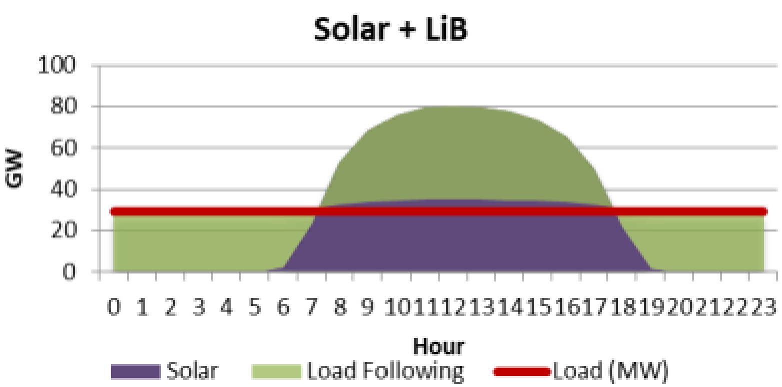
- **SCOPE 1** ‘Direct’: Direct emissions from “Usage” of the owned or controlled sources
- **SCOPE 2** ‘Indirect’: Indirect emissions from the generation of the energy sources
- **SCOPE 3** ‘Up/Downstream Effects’: All indirect emissions that occur in the value chain (upstream/downstream) of the sources

	SCOPE 1	SCOPE 2	SCOPE 3
Gas (CC/CT)	✓	✓	✓
Coal	✓	✓	✓
Nuke	No Emissions	Water Vapor? ✓	✓
RE (Wind/Solar)	No Emissions	✓	✓
Energy Storage (LIB)	No Emissions	✓ **GHG Emissions from re-charging diminishes over time** → ✓	✓

GHG Comparison of Generation Sources







	CAPEX[1] ($B)	Scope 1,2[2] (MMT CO_{2e}) Day 1	Scope 3[2] (MMT CO_{2e}) Day 1
Combined Cycle	49	0.26	10
Solar + CT	158	0.34	197
Wind + CT	182	0.27	75
Solar + LiB Grid - Connected	518	0.30	657
Wind + LiB Grid-Connected	325	0.23	141

More material inputs (Scope-3 emissions) are created for RE versus the existing fossil fuel infrastructure.

Life-Cycle Analysis will become critical to assess the scope 1-3 emissions of a continuous cycle of build, maintain, replace to keep the RE machine going.

Note: Values reflect empirical seasonal and hourly variation in load and generation and average NERC grid reliability. Source: CAISO.

[1]From LAZARD's Levelized Cost of Energy v12 and Levelized Cost of Storage v4

[2]NREL Life Cycle Greenhouse Gas Emissions from Solor Photovoltaics, NREL Wind LCA Harmonization, IVL The Life Cycle Energy Consumption and GHG from LiB

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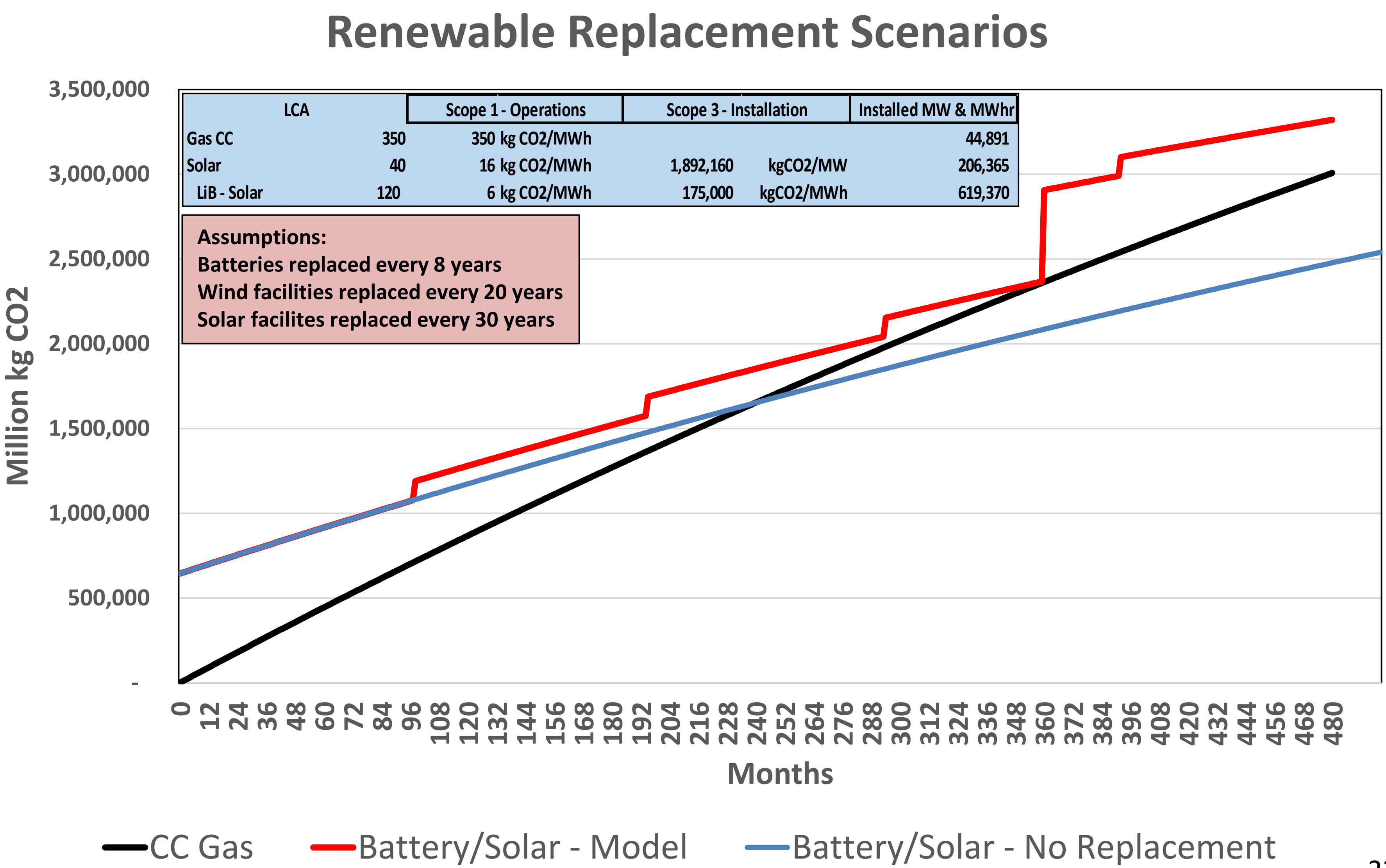
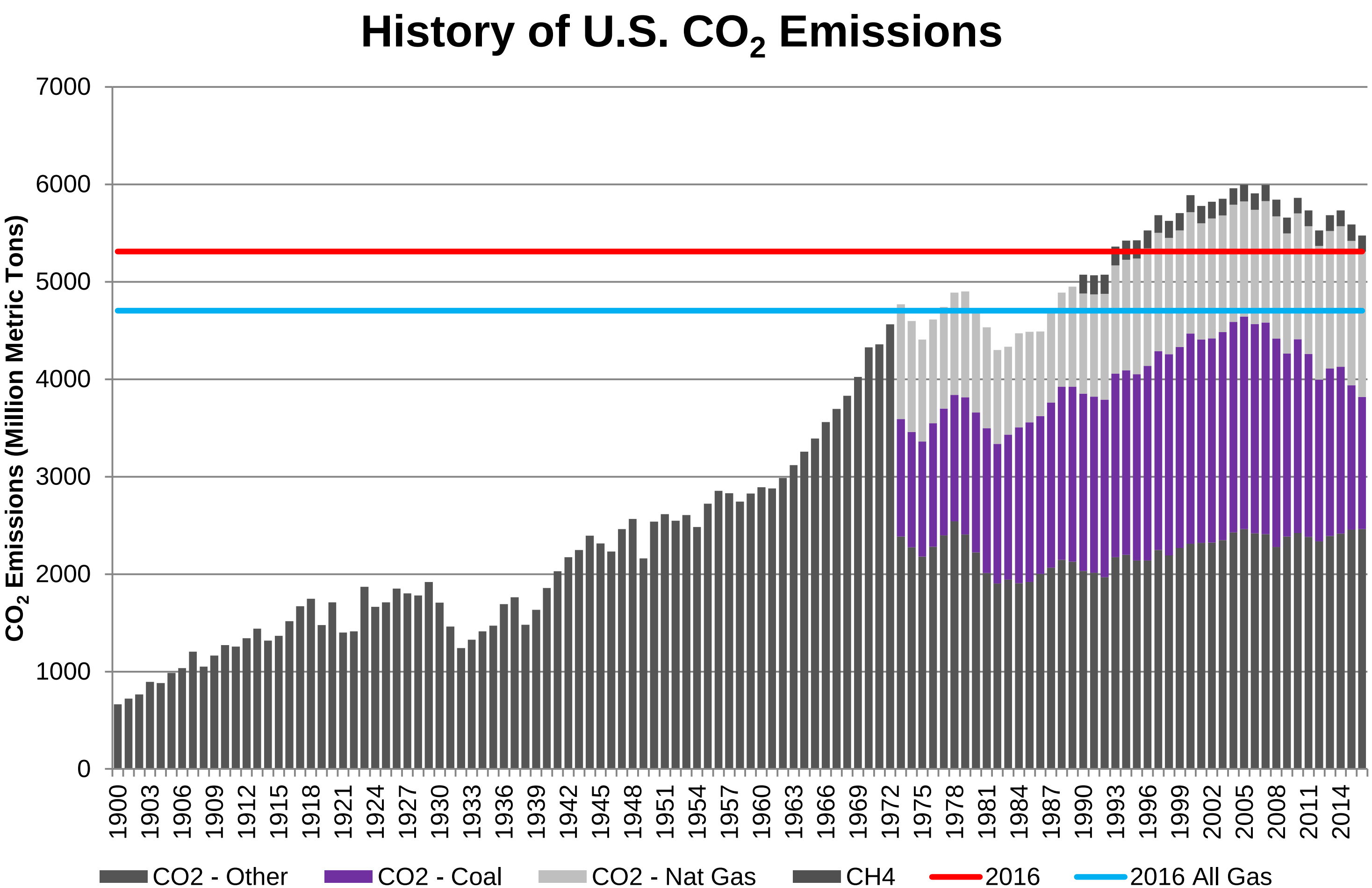
Emissions Comparison



U.S. CO_2 Emissions



Greater natural gas fired generation has helped the U.S. reduce CO_2 emissions

Replacing all remaining coal generation with natural gas generation would reduce U.S. CO_2 emissions to pre-1987 levels

Reductions in coal-fired generation have been largely responsible for reductions in CO_2 emissions.

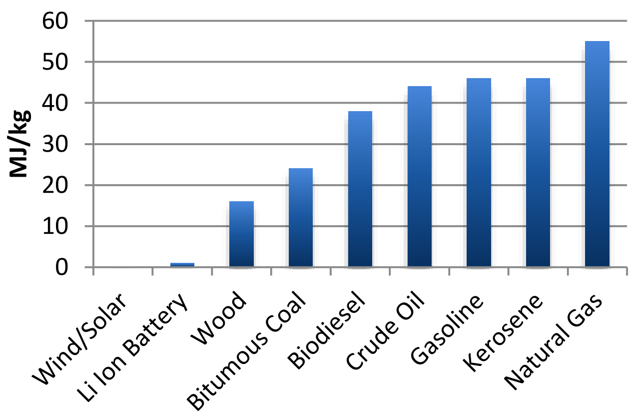
CO_2 emissions grew steadily though 2006 but have been falling as a result of the shale gas revolution and displacement and retirement of coal generation.

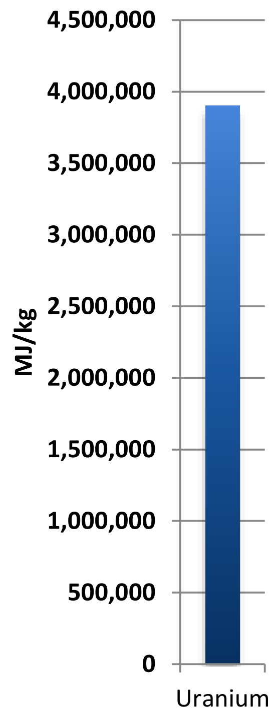
Source: EIA, EPA, Oak Ridge National Laboratory

Comparative Energy Densities

Energy Density

Source	MJ/kg
Wind/Solar	0.00006
Li Ion Battery	1
Wood	16
Bitumous Coal	24
Biodiesel	38
Crude Oil	44
Gasoline	46
Kerosene	46
Natural Gas	55
Uranium	3,900,000





Land Area to Meet 100% of 2018 U.S. Power Generation

Solar + Battery =

Wind + Battery =

Natural Gas =

Note: Land Area for equivalent generation at 99% reliability. Natural gas land area includes power plant + sand production + natural gas wells. Solar and Wind land areas do not include land use for mining, manufacturing, or disposal.

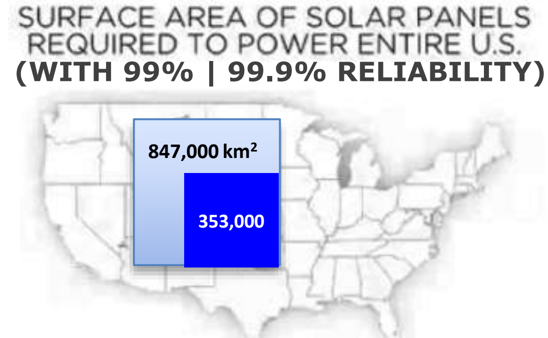
Source: CHBC 2015; NREL 2013b; FCH Jun 2015, EIA, Natural Gas Supply Assoc., NREL

We Need a Bigger Blue Square

2,270 GW capacity
$2.3 Trillion CAPEX[8]
4.0 Billion MT CO_2e[9]

Natural Gas CC:
3,400 km^2
718 GW capacity
$718 Billion CAPEX[8]
1.5 Billion MT CO_2e/year

The Math:	Source
4,171[1] TWh/year	EIA 2018 U.S. Power Generation
476 GW	$\frac{4{,}171\ \text{TWh/yr}}{8{,}760\ \text{hrs/yr}}$
21% Load Factor	NREL PVWatts for N. TX[2]
0.24 GW/km^2	1 kW/m^2 x 24% module efficiency[3]
9,400 km^2	$\frac{476}{0.24 \times 0.21}$



9,880 GW capacity
$9.9 Trillion CAPEX[8]
18 Billion MT CO_2e[9]

23,720 GW capacity
$23.7 Trillion CAPEX[8]
42 Billion MT CO_2e[9]

NOTE: Excludes Energy Storage Cost, CO_2e, and Land Area

The Math:	Source	Factor
14.24 TWh[4]	EIA Peak day U.S. L48 Demand on 8/11/2016	Not used
593 GW	$\frac{14{,}240\ \text{GWh}}{24\ \text{hrs}}$	x 1.25
6.0% | 2.5% Load Factor	L48 load factor at 99% | 99.9% confidence[5] using EIA hourly generation and installed capacity. U.S. L48 avg. solar load factor is 17%[6]	x 3.5 | x 8.4
0.028 GW/km^2	NREL Total Solar Area factor[7]	x 8.57
353,000 km^2 | 847,000 km^2	$\frac{593}{0.06 \cdot 0.028} \Big\vert \frac{593}{0.025 \cdot 0.028}$	x 38| x 90

[1]EIA 2018 Total Power Generation 4,171 TWh https://www.eia.gov/tools/faqs/faq.php?id=427&t=3
[2]https://pvwatts.nrel.gov/pvwatts.php
[3]Green et al, Solar Cell Efficiency Tables (Version 45), Table 2, GaAs (thin film)
[4]EIA Real Time Grid

[5]NERC 2018 grid reliability was 99.92%
[6]Load factor from NREL's PVWatts is 17.5% in center of U.S. (Kansas)
[7]NREL "Land Use for Solar Power Plants in the United States" page 17 shows 8.9 Acres/MW
[8] Lazard's Levelized Cost of Energy Analysis Version 13.0, using avg. CAPEX value
[9]40 kg/CO2e/MWh per NREL Life Cycle Greenhouse Gas Emissions for Solar Photovoltaics

Power vs. Natural Gas Transmission

Conduit	Capacity (MW)	1 Bcfd Pipeline Equiv. Factor	Pipeline Equiv. Cost ($MM/mile)	Pipeline Equiv. Line-Loss (%/100 miles)
1 Bcfd gas pipeline	4,750	x1.00	$3.9	0.3%
600 kV HVDC	3,500	x1.36	$7.2	0.7%
765 kV HVAC	2,300	x2.07	$7.1	1.7%
500 kV HVAC	900	x5.28	$15.6	6.9%
345 kV HVAC (double)	750	x6.33	$13.2	26.6%

Natural gas pipelines are more efficient and more cost-effective than power transmission

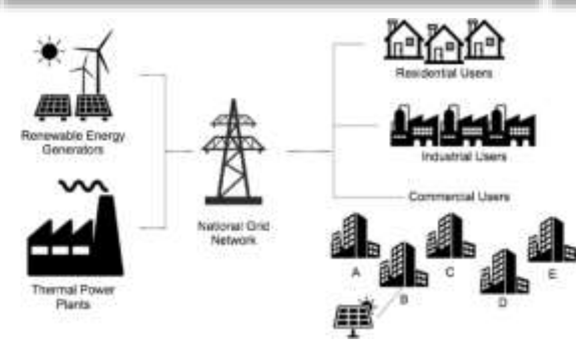
Growth in renewables (typically located far away from major load centers) and electrification requires significant investment in new power transmission

Sources: ICF International Transmission assessment for EIA June, 2018; AEP Transmission Facts; KM analysis

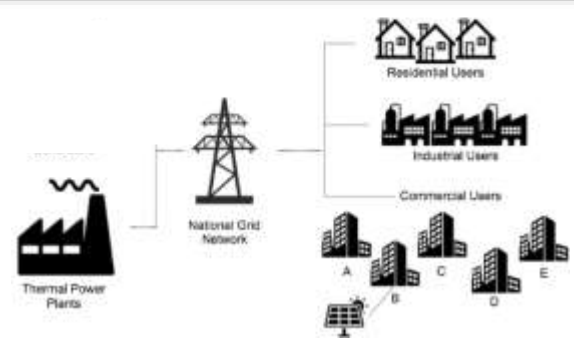
Let’s Compare Apples to Apples

“Current” Narrative	“New” Narrative	Benefits / Differences
Capacity	Deliverability	Grid Reliability & Resiliency
Per Unit Cost (LCOE)	**Total System Cost**	LCOE ≠ Total Cost of Equivalent Performance
“Tailpipe” Emissions (Scope 1)	**Total System Emissions**	It’s **TOTAL EMISSIONS** that matter
	Brownfield vs. Greenfield	Scope 1 vs. Scope 1 - 3
	A full LifeCycle Assessment (LCA)	Although imperfect, an LCA per MWh of load served must be performed in order to achieve consistent comparison of investment alternatives

VS.

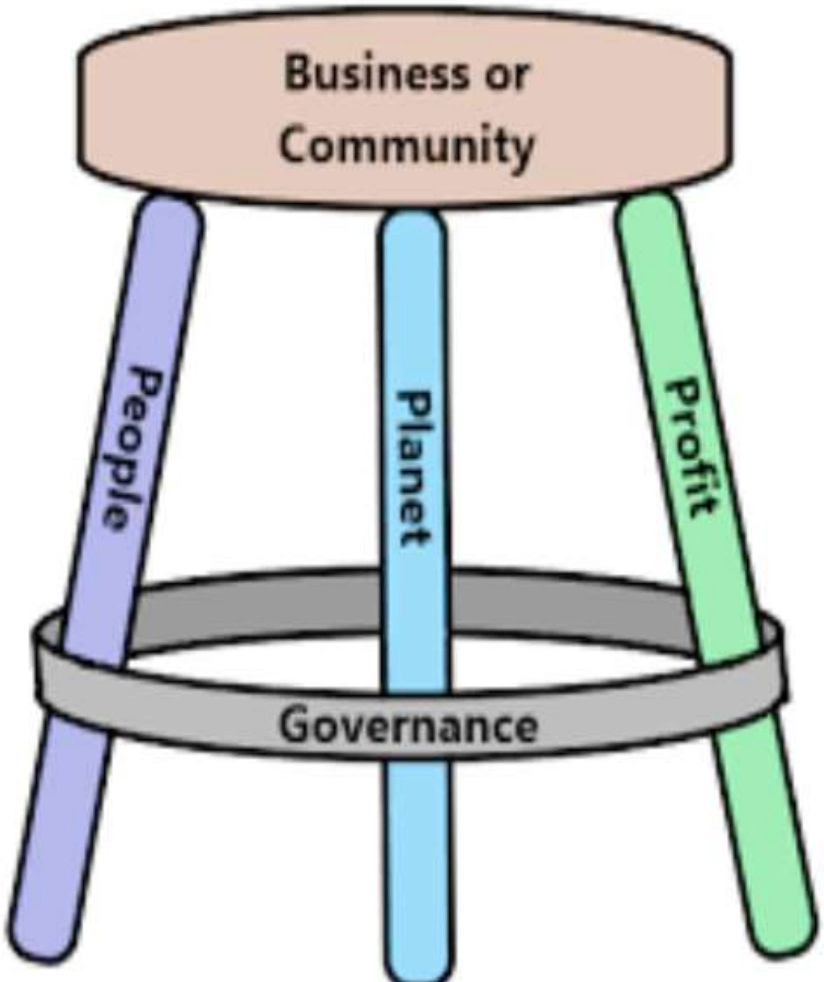


VS.



The Industry needs to influence policy makers at all levels (Federal/State/Local) to embrace new narrative when discussing clean energy and climate related goals.

Environmental, Social, Governance (ESG)



- Maintain Balance
  - Natural gas infrastructure is needed for deliverability and new markets
  - Access to low cost, clean, abundant energy is beneficial to everyone
- Out of Balance
  - States misguided energy ideology
  - Retirement of gas infrastructure and replacement with renewables
  - Consequences
    - Reliability concerns
    - In the Northeast, imported LNG and fuel oil still being used
    - In the West, gas/diesel portable generation sales growing at record pace
    - Emissions are increasing (Scope 3)
    - Driving up energy costs to ratepayers (Utilities, Food, Transportation, etc.)

Bill Gates – Stanford University 2019

Summary

- The clean energy future is real and gathering pace through a combination of renewable energy technology advancements and state, national, and global climate change initiatives
- Natural Gas is abundant, clean, cheap, efficient, dispatchable = reliable
- Natural gas pipelines facilitate and accelerate the penetration of renewable energy by providing
  - Essential reliability and resiliency
  - Cost effective generation to maintain affordable rates for consumers
- Natural gas and the infrastructure to deliver it also have been the primary source of reductions in GHG emissions and will continue to be a critical part of the clean energy future

We Must 'Go Honest' to 'Go Green' – University of Texas, Austin

Scott Tinker, PhD in Geological Sciences, **University of Colorado, Boulder**

https://news.utexas.edu/2021/01/21/we-must-go-honest-to-go-green/

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Natural Gas Role in the Clean Energy Future

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Vice President, Commercial
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Delivering Energy to Improve Lives and Create a Better World

APPENDIX

Delivering Energy to Improve Lives and Create a Better World

My Career Timeline

Phillips Petroleum Co
Drilling/Production Engineer

Phillips Petroleum Co
Gas Processing Engineer

Coastal Corporation
Project Engineer

El Paso Corporation
System Design Engineer

El Paso Corporation
Account Representative
Marketing

El Paso Corporation
Director, Marketing
Rockies Region

Kinder Morgan
Director, Marketing
Rockies/DSW

Kinder Morgan
Vice President,
Business Management
West Region

Kinder Morgan
Sr. Vice President,
West Region

Borger, Texas — Midland, Texas — Colorado Springs, CO

1992 1997 1999 2004 2005 2009 2012 2016 2020

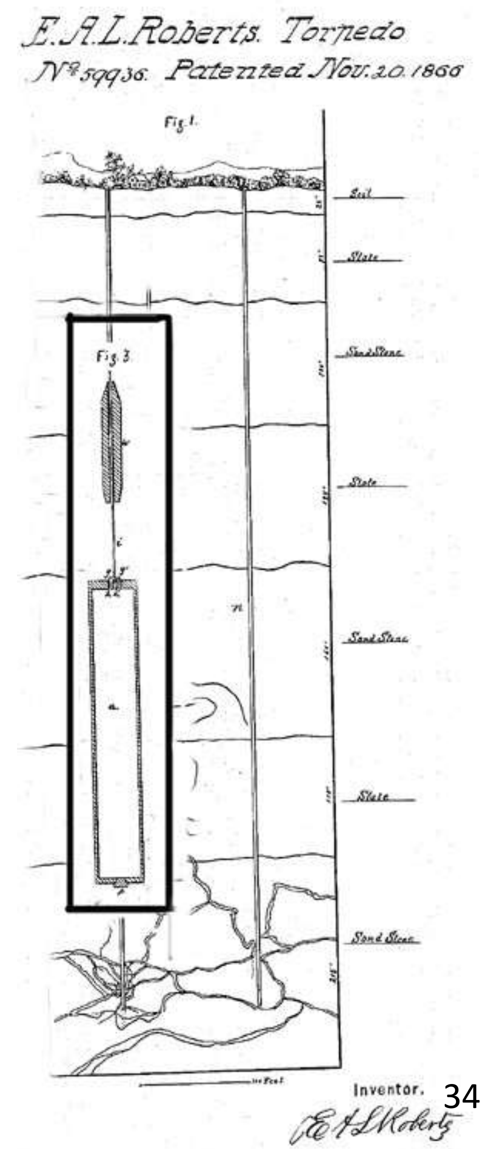
BSME
CU Boulder

Professional
Engineering License
Texas

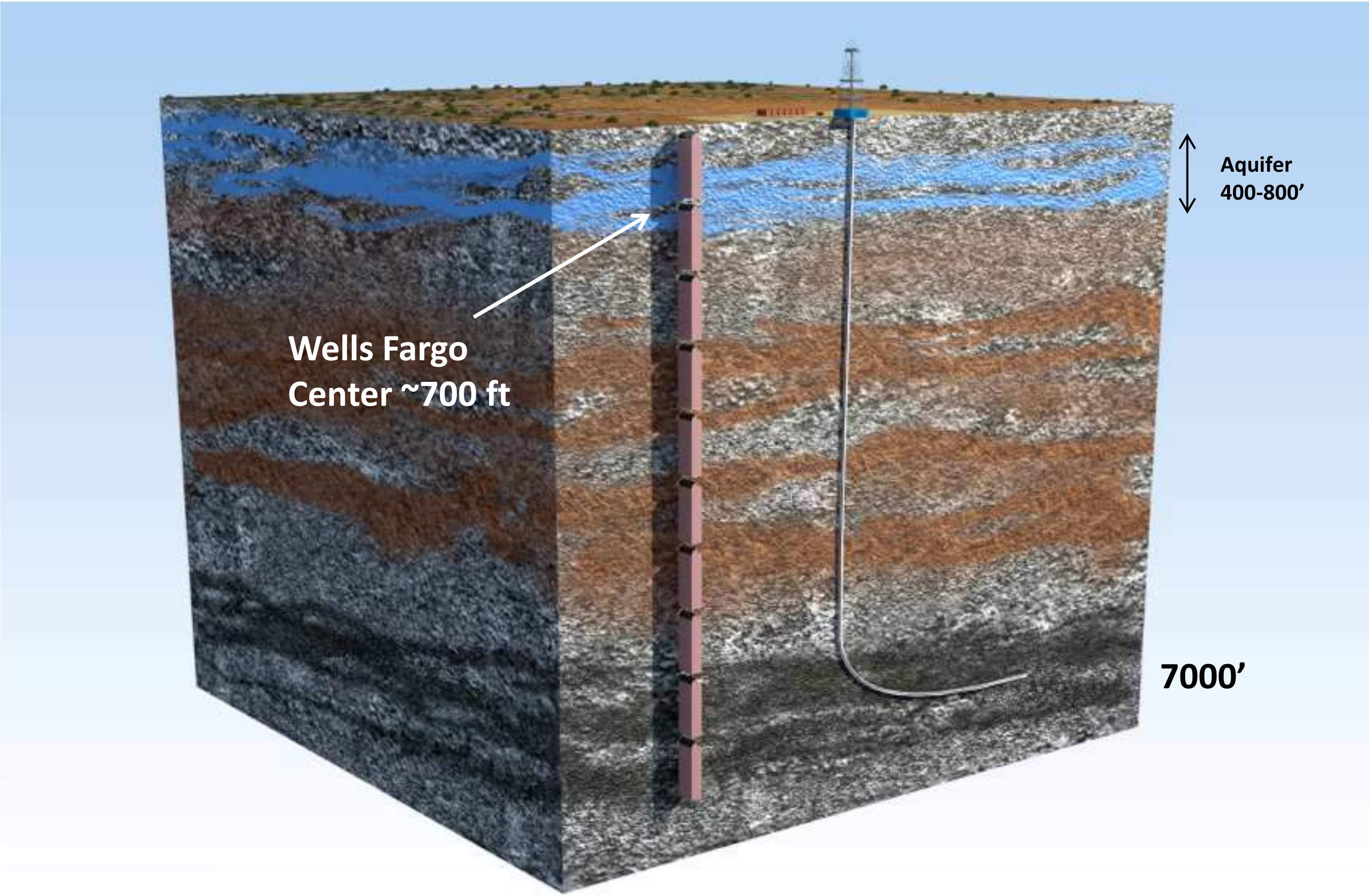
MBA Finance
CU Colorado Springs

Hydraulic Fracturing

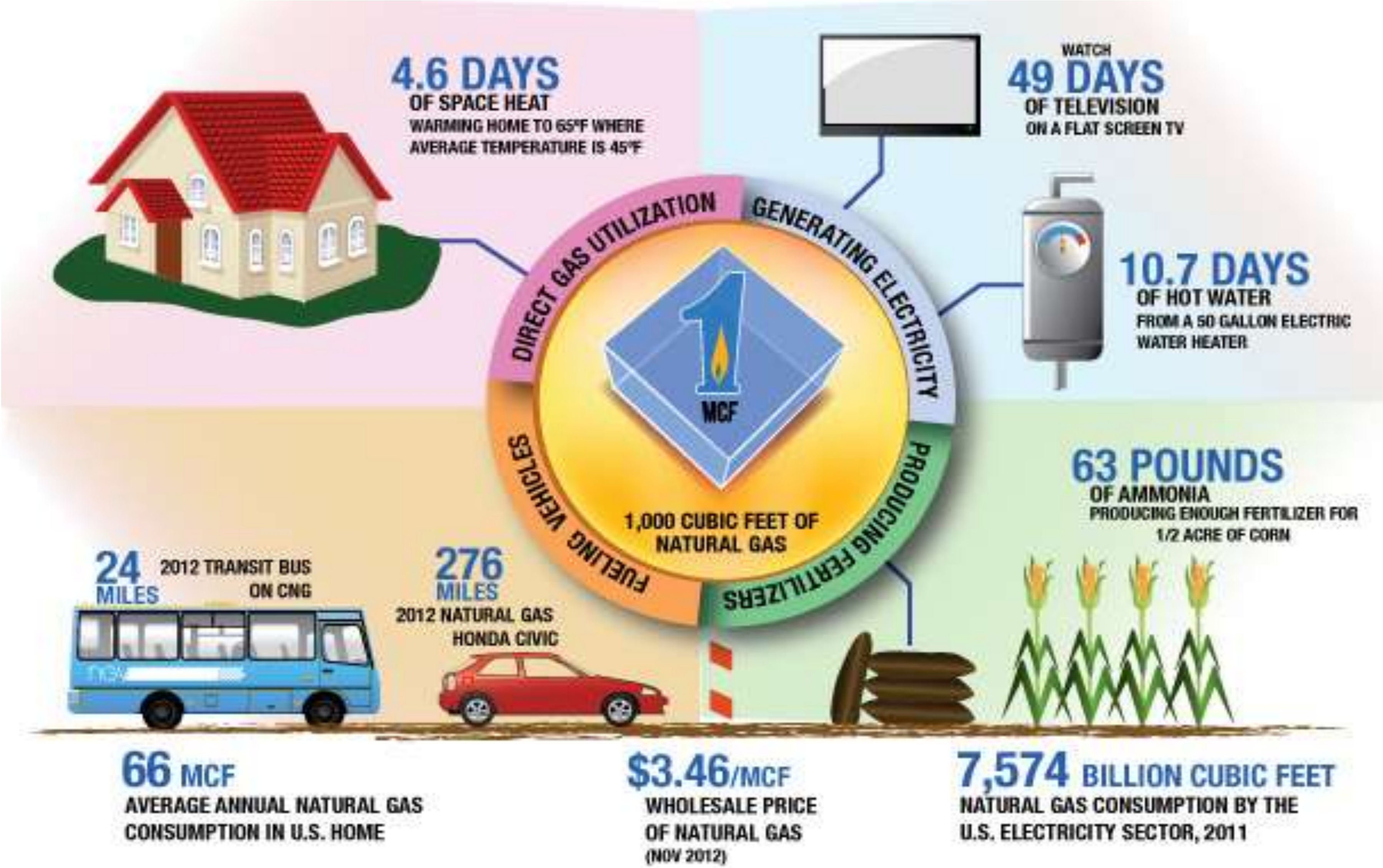
- Hydraulic Fracturing
  - The use of fluids to create a crack by hydraulic pressure
  - The continued injection of fluids into the created crack (or “fracture”) to increase its size
  - The placement of small granular solids into the fracture to keep it open
- Civil War veteran Col. Edward Roberts (fought in the 1862 battle of Fredericksburg)
- Invented the Roberts Torpedo in 1866
- The U.S. has been employing hydraulic fracturing technologies for over 154 years!



Geology



What Does One Mcf of Natural Gas Get Us?



American Clean Skies Foundation

Lets talk about Physics and Thermodynamics

- Hydrocarbons supply 84% of the worlds energy and have superior energy density
- Renewables provides approximately 3% of the US energy and growing
- Solar and Wind Technologies have improved but are approaching the physics boundary
  - Solar PV cells have max conversion of 34% photons into electrons (Shockley-Queisser Limit) (currently ~26%)
  - Wind physics boundary for kinetic energy capture of 60% (Betz Limit) (currently ~40%)
- Batteries are not the long term solution for grid stability and reliability
  - $200K of Tesla LIB (20K lbs) = one barrel of oil stored in a $20 tank weighing 300 lbs
  - 50-100 lbs of materials are mined, moved and processed (via hydrocarbons) for 1 lb
  - Today, annual output of Tesla's Gigafactory could store 3 minutes worth of US electricity demand. 2 days of storage, would require 1,000 yrs to make enough LIBs.
- Moore's Law Misapplied: Physics realities do not allow energy domains to undergo the kind of revolutionary change experienced on the digital frontiers
  - LIB scaled by Moore's Law: book size battery, 3 cents, could power an A380 to Asia
- No matter the precise pace and scope of the energy transition, it is almost sure that it will be more mineral and metal-intensive than the current system

The New Energy Economy An Exercise in Magical Thinking - Mark P. Mills, Senior Fellow, Manhattan Institute Report, March 2019
The Payne Institute for Public Policy, Colorado School of Mines, Feb., 28, 2019; WSJ: If You Want Renewable Energy, Get Ready to Dig, by Mark P Mills.

The Natural Gas Industry

- Exploration & Production
  - Finding and extracting hydrocarbons from subsurface geologic formations
- Gathering
  - Transporting raw hydrocarbons, via small diameter pipelines, from wells to processing facilities or interstate transmission lines
- Processing
  - Treating raw hydrocarbons to remove undesirable impurities and extract commercially desirable hydrocarbons (natural gas, butane, propane, etc.)
- Interstate Transmission
  - Transporting natural gas long distances through large diameter, high pressure pipelines
- Local Distribution
  - Transporting natural gas to the ultimate consumers (heating, power generation, industrial, etc.)

Pipeline Capability and Deliverability