Award Winning

The Override

Every Landman Wants One!

Volume XII, Issue I | September, 2019

LAAPL
LOS ANGELES ASSOCIATION OF PROFESSIONAL LANDMEN

Presidents Message

Jessica Bradley, RPL
President
Warren E&P, Inc.

For so many, September signifies the dawning of a new year. Sure, a calendar will tell us differently. A new year begins January 1st. However, there is something that feels new when September arrives. Summer vacation is over, children return to school, and the air offers that unmistakable crispness synonymous with the coming of fall. Fall brings with it a fresh start and room for infinite possibilities. Children report to class with fresh school supplies, sharpened pencils, and brand new erasers. And maybe, a new outfit or two for school. Adults are reminded that the year is almost over. There are four months remaining to accomplish the goals that you set at the start of the year. Four months remain to pursue your objectives and achieve them.

It is my great honor and privilege to step into the role of President of the Los Angeles Association of Professional Landmen (LAAPL). I honor Mike Flores, LAAPL Immediate Past President, for his exceptional service as President for the 2018-2019 term. I look forward to working beside the exceptional Board Members that serve the Association with their dedication, expertise, and professionalism.

Perhaps you have already achieved the goals you set at the beginning of the year. If you have, I salute you. If the year has gotten away from you, take heart. There is still time. Dust off that vision board, your planner, or that list of 2019 "to-dos" that you typed in your Notes page back in January. Guess what? Nothing is impossible, and I have every confidence in you. Prove yourself wrong. Be a better you today than the person you were yesterday. You've got this! Go get 'em.

Inside This Issue:

~ Click on a topic to take you to that article ~

Meeting Luncheon Speaker

AB 585 New Law Affecting Assignments of Oil and Gas Leases on Calif. Public Land – What's a Landman to do?

L. "Rae" Connet is an active member of AAPL, LAAPL, a practicing attorney and the co-founder of PetroLand Services, a land consulting firm serving oil and gas producers, utility companies, mineral owners, governmental agencies and real estate developers across multiple states. Combining her strong legal background and training with the practical skills of a working land professional, Rae brings 28 years of experience and expertise to serve the company's clientele. Rae also represents the company's clients before regulatory agencies dealing with land use, zoning and planning issues, drilling and facilities permitting related to oil and gas facilities. Law Degree: JD, Loyola Law School, Los Angeles; Admitted to Practice in All California Courts, The United States District Court for the Central District of California & The Ninth Circuit Court of Appeal.

Opinionated Corner

Joe Munsey, RPL
Director
Publications/Newsletter Co-Chair
Southern California Gas Company

We forego our column and are dedicating this issue of *The Override* in memory of long time LAAPL member and supporter, Bill A. Mickelson, Jr., CPL., whose well known and highly respected brokerage firm, Mickelson Land Services, was acknowledged by all. Bill was a consummate professional landman extraordinaire.

May he rest in peace.

LAAPL Receives Award

"The Override," the official organ of the LAAPL took first place (small chapter association category) at the AAPL convention in Pittsburg, PA. Attending the ceremony and accepting the award on the chapter's behalf was Randall Taylor, RPL, of Taylor Land Services. The newsletter has outstanding contributing writers, but it goes without saying that Randall Taylor, RPL, of Taylor Land Services, Co-chair of the Publication/Newsletter, does all the heavy lifting when it comes to publishing this fine communication tool.

Randall Taylor, RPL accepting awards with others

Bill A. Mickelson, Jr., Ret. CPL

The Los Angeles Oil Patch lost one of its best in February of this year. Bill A. Mickelson, Jr., Ret. CPL, landman, golfer, and a beloved gentleman in our industry passed away on February 16, 2019, at the age of 91.
Bill was one of the founders of the Los Angeles Association of Professional Landmen (LAAPL) and during the struggling times helped keep the association going.

Whenever you're doing your due diligence in any part of the LA Basin, you do not have to look too far before you run across a title report written by Bill Mickelson. He was one of the busiest and best landmen of his time.

Bill was a consummate professional and the epitome of "Old School." All his correspondences were either typed or handwritten. He did not have an email address. He believed in non-computer communication, preferring letters and telephone calls to electronic mail. Because he did not have an email address, I would send the current newsletter by regular mail, and always received a "thank you" note written on the cover letter I sent with the newsletter. Bill was part of a fading breed of elites who consistently practiced professional courtesy at every turn. Sadly, the art of professional courtesy is not as prevalent today, as it was in Bill's heyday.

Bill will be sorely missed by all those who knew and loved him. Thankfully, we have our annual association fund raiser, the LAAPL Mickelson Golf Classic, to keep his cherished memory alive in our hearts and minds.

Until we meet again

2019—2020 Officers & Board of Directors

President
Jessica Bradley, RPL
Warren E&P, Inc.
562-800-0062

Vice President
Randall Taylor, RPL
Taylor Land Service, Inc.
949-495-4372

Past President
Mike Flores
Championship Strategies, Inc
310-990-8657

Secretary
Marcia Carlisle
The Termo Company
562-279-1957

Treasurer
Jason Downs, RPL
Chevron Pipeline & Power
858-699-3353

Director
Joe Munsey, RPL
Southern California Gas Company
949-361-8036

Director
Ernest Guadiana, Esq.
Elkins Kalt Weintraub Rueuben Gartside LLP
310-746-4425

Region VIII AAPL Director
Randall Taylor, RPL
Taylor Land Service, Inc.
949-495-4372

Newsletter/Publishing Chair
Joe Munsey, RPL, Co-Chair
Randall Taylor, RPL, Co-Chair

Communications/Website Chair
Chip Hoover
Independent
310-795-7300

Membership Chair
Allison Foster
Signal Hill Petroleum
562-326-5220

Education Chair
Courtney Childress, RPL
The Mineral Advocate, LLC
(855) 526-3636

Legislative Affairs Chair
Mike Flores
Championship Strategies, Inc
310-990-8657

Legal Counsel
Ernest Guadiana, Esq.
Elkins Kalt Weintraub Rueuben Gartside LLP
310-746-4425

Golf Chair
Jason Downs, RPL
Chevron Pipeline & Power
858-699-3353

Chapter Board Meetings

The LAAPL Board of Directors and Committee Members held their regular meeting on Thursday, May 16, 2019 led by President Mike Flores. The topics discussed at the meeting are as follows:

- Mike Flores called for the election of the 2019-2020 Officers and Directors. Sarah Bobbe counted ballots and certified the current duly elected LAAPL Officers.
- It was voted to provide a deposit for the Michelson Golf 2019 event. (This successful Golf Classic was held June 27, 2019 at the Sand Canyon Country Club with proceeds benefiting the R. M. Pyles Boys Camp).
- Treasurer, Jason Downs, requested $1,000 to promote the AAPL 2020 National Convention to be held in Huntington Beach.
- A deposit was approved to secure our new meeting venue, The Grand, Long Beach.
- Eight new member requests were approved.

We encourage all members to attend our LAAPL Board Meetings which are typically held in the same room as the luncheon immediately after the meetings are adjourned.

Scheduled LAAPL Luncheon Topics and Dates

September 19, 2019

Rae Connet, Esq

November 21, 2019
TBD

January 16, 2020
~ Joint Meeting with Geologists ~

March 19th, 2020
Jay Beavers, AAPL President

May 21, 2020

Treasurer's Report

Jason Downs, RPL
Treasurer
Contract Senior Land Representative
Chevron Pipe Line and Power

As of 6/14/2019, the LAAPL account showed a balance of	34,477.17
Deposits	7,621.70
Total Checks, Withdrawals, Transfers	-1,129.18
Balance as of 9/9/2019	**40,969.69**

LAAPL 2019-2020 Officers

At our May 2019 luncheon, the LAAPL members voted in for office:

President
Jessica Bradley, RPL,
Warren E&P, Inc.[1]

Vice President
Randall Taylor, RPL
Taylor Land Services, Inc.

Past President
Mike Flores
Championship Strategies, Inc.[2]

Secretary
Marcia Carlisle
The Termo Company

Treasurer
Jason Downs, RPL
Chevron Pipeline & Power

Director
Joseph D. Munsey, RPL
Southern California Gas Company Co.

Director
Ernest Guadiana, Esq.
Elkins Kalt Weintraub Reuben Gartside LLP

Director
Mike Flores
Championship Strategies, Inc[3]

[1]Per Section 7(3) the Vice President shall succeed to the office of the President after serving his or her term as Vice President and shall hold the office of President for the next twelve (12) months.
[2]Per Article 8 (2) the outgoing President shall serve as director.
[3]Per Article 8 (2) the outgoing President shall serve as Director

Lawyers' Joke of the Month

Jack Quirk, Esq.
Bright and Brown

Sally was driving home from one of her business trips in Northern Arizona when she saw an elderly Navajo woman walking on the side of the road. As the trip was a long and quiet one, she stopped the car and asked the Navajo woman if she would like a ride. With a silent nod of thanks, the woman got into the car.

Resuming the journey, Sally tried in vain to make a bit of small talk with the Navajo woman. The old woman just sat silently, looking intently at everything she saw, studying every little detail, until she noticed a brown bag on the seat next to Sally. 'What in bag?' asked the old woman. Sally looked down at the brown bag and said, 'It's a bottle of wine. I got it for my husband.' The Navajo woman was silent for another moment or two. Then speaking with the quiet wisdom of an elder, she said:

'Good trade.....'

Our Honorable Guests

May's luncheon was another successful LAAPL Chapter meeting, held for the first time at The Grand Long Beach. Our presenters and guests of honor:

Ronald Stein, P.E. - PTS Advance

Todd Royal, M.P.P. - Author, researcher, consultant

2020 ANNUAL MEETING

June 17-20
Huntington Beach, CA

landman.org

Save the Date brought to you by:

BAPL
BAKERSFIELD ASSOCIATION OF PROFESSIONAL LANDMEN

LAAPL
LOS ANGELES ASSOCIATION OF PROFESSIONAL LANDMEN

LAAPL Members Involved With 2020 Huntington Beach Convention

AAPL President, Jay Beavers, CPL, appointed two LAAPL members to serve as chairmen for the 2020 AAPL convention to be held in Huntington Beach.

Jason M. Downs, RPL, AAPL Annual Meeting Committee Chairman. The following California Oil Patch professionals make up a portion of the committee:

[Alphabetical Order]

- ✓ Lance Burton, Chevron U.S.A., Inc.
- ✓ Ashley Claunch, Chevron U.S.A., Inc.
- ✓ Allison S. Foster, Signal Hill Petroleum, Inc.
- ✓ John Harris, Esq., Locke Lord LLP
- ✓ Blain P. Meith, California Resources Corporation
- ✓ Richard "Rick" Peace, White Wolf Land Services
- ✓ Michael Sherman, Esq., Day Carter Murphy
- ✓ Randall Taylor, RPL, Taylor Land Services, Inc.

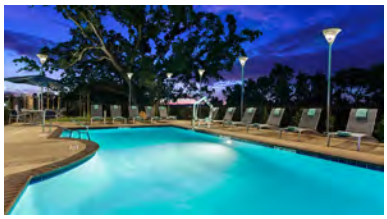
Joseph D. Munsey, RPL, AAPL Education Annual Meeting/Seminar Chairman. The following California Oil Patch professional makes up a portion of the committee:

- ✓ Jason M. Downs, RPL, Chevron Pipeline & Power, Annual Meeting Committee Chair (Ex-Officio)

SAVE THE DATE FOR THE

37TH ANNUAL

WEST COAST LANDMEN'S INSTITUTE



When:

Wednesday – Friday, September 25 – 27, 2019

Where:

SpringHill Suites Paso Robles Atascadero

900 El Camino Real, Atascadero, California 93422 USA

Dinner is slated for Thursday Night at *Giuseppe's Cucina Italiana*

Details to follow!

Book Review

"The Taking of Getty Oil"

Reviewed by Thomas C. "TC" Turner, Esq.

A blast from the past chock full of inter-generational family intrigue, corporate plotting, and larger than life titans of 1980's Wall Street capped off by the largest jury award in American history, *The Taking of Getty Oil* is not to be missed. The book is an astute mixture of juicy family politics found in the pages of *The Big Rich* mixed with the corporate intrigue and maneuverings of a John Grisham novel. Despite knowing the outcome, I couldn't put it down once I started.

Steve Coll's meticulously researched book traces the events, personalities and conflicts that led to the sale of the Getty Oil Company and the subsequent conflict between Pennzoil and Texaco over the deal. The tale pits the career-minded executives of Getty Oil, led by chairman and chief executive Sid Peterson, against the musically gifted, accidental heir to the sole trusteeship of the Sara C. Getty Trust, Gordon Getty, who can be described as mercurial at best, and capricious at worst. In between are appearances by industry legends such as the Cullen family, and T. Boone Pickens, as well as West Texas favorite Hugh Liedtke and master trial lawyer Joe Jamail. This cast is supplemented by the able support of Wall Street legends such as Marty Lipton, the father of the corporate takeover, wunderkind Marty Siegel of Kidder, Peabody & Co., Geoff Boisi of Goldman, Sachs & Co., and numerous others, as well as bit parts by Houston blue blood law firms Baker Botts and Vinson & Elkins.

Publisher's Weekly Review can be found HERE.
http://www.publishersweekly.com/978-0-689-11860-9

Kirkus Review can be found HERE.
https://www.kirkusreviews.com/book-reviews/steve-coll-2/the-taking-of-getty-oil/

For more on the Texaco-Pennzoil war, see Thomas Petzinger, Jr.'s Oil and Honor.

TC Turner is a partner in the Houston office of Kean Miller. His Energy and Natural Resources practice involves transactional, land title, operational, and regulatory matters. He is routinely involved in the full life cycle of a prospect, from initial due diligence and acquisition, to title examination, curative, operations advisement, and final divestiture. T.C.'s clients include large oil and gas producers, environmental service companies, mineral and royalty buyers, and renewable energy companies. If it involves complex real property issues, T.C. is involved. An active writer, he is Assistant Chairman of the AAPL Publications Committee. He encourages you to reach out to him at tc.turner@keanmiller.com.

AAPL Director Report

Randall Taylor, RPL
AAPL Director, Region VIII

The most recent meeting was held on June 18-19, 2019 at the Wyndham Grand Downtown Hotel in Pittsburg, PA. The hotel was a decent venue and the Annual meeting which took place at the same time was a resounding success.

- Kudos to Mark Acree, the Annual Meeting Committee, Michele Aurzada, the Education Committee and the AAPL Staff.
- During the Business Meeting, David Miller, Cranford Newell, Aaron Yost, Chuck Walton and Mike Pisciotte were thanked for a job well done. The gavel was ceremoniously transferred from Mike Curry to Jay Beavers. Mike Curry (Immediate Past President), Lester Zitkus (1st VP), Wendy Dalton (2nd VP), Sean Marchall (3rd VP), Brittney Crookshanks (Secretary) and Jason Maloy (Treasurer) were introduced as your new Executive Committee.
- Mike Pisciotte reported that, as of March 31, 2019: AAPL, Inc. had total assets of $35,427,836; AAPL Educational Foundation, Inc. had total assets of $4,261,865; and the AAPL Landman Scholarship Trust had total assets of $7,505,592; so that the combined total assets of all three entities is $47,195,293.
- The resignation of the Black Warrior Association of Professional Landmen was accepted by the AAPL Board of Directors.
- Thanks to Bob Bergfeld and the Awards Committee. EOG Resources Inc. received the 2019 Pioneer Award. Hamel Reinmiller is AAPL Landman of the Year. Jim McGowen was presented with the Lifetime Achievement Award.
- Melanie Bell announced her resignation as Executive VP of AAPL, effective at the end of the calendar year. Melanie has served the AAPL with dignity and a high level of professionalism. Melanie has been extremely loyal and dedicated to the AAPL and will be missed by all of us.
- Our highest priority is to hire Melanie's replacement prior to the December Board Meeting. David Cape has agreed to chair the EVP Search Task Force. David will be selecting the task force members this week. The members of this task force will remain confidential.
- The current AAPL membership is **14,320.**
- Registration for 2020 NAPE Summit is open.
- A great big THANK YOU to Jodi Gallegos, David Cape and the EVP Task Force for locating an outstanding candidate to replace Melanie Bell.
- Registration is open for the Advanced Landman's Institute at the Hyatt Regency Galleria in Houston, Texas on November 7-8, 2019. This is an advanced seminar being produced jointly by the AAPL and the Rocky Mountain Mineral Law Foundation.

New Members and Transfers

Allison Foster
Membership Chair
Signal Hill Petroleum, Inc.

Welcome! As a Los Angeles Association of Professional Landmen member, you serve to further the education and broaden the scope of the petroleum landman and to promote effective communication between its members, government, community and industry on energy-related issues.

New Members (Active)

Courtney Childress, RPL
Founder/CEO
The Mineral Advocate
23412 Moulton Parkway #240
Laguna Hills, CA 92653
courtney.childress@themineraladvocate.com
Bus. Phone: 855.526.3636

Abbey Cyester
Associate Landman
The Mineral Advocate
23412 Moulton Parkway #240
Laguna Hills, CA 92653
abbey.cyester@themineraladvocate.com
Bus. Phone: 855.526.3636

Kimberly D. Bridges, CPL
Senior Landman
Sentinel Peak Resources
1200 Discovery Drive, Suite 100
Bakersfield, CA 93309
Bus. Phone: 661.395.5278

New Members (Associate)

Cecilia E. Rendon
Attorney
Bright and Brown
500 N. Brand Blvd., Suite 2100
Glendale, CA 91203
crendon@brightandbrown.com
Bus. Phone: 818.243.2121

Kristin G. Taylor
Attorney
Bright and Brown
500 N. Brand Blvd., Suite 2100
Glendale, CA 91203
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Bus. Phone: 818.243.2121

Brian L. Becker
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MacKenzie E. Hunt
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Glendale, CA 91203
mhunt@brightandbrown.com
Bus. Phone: 818.243.2121

Gregory P. Hunt
Attorney
Bright and Brown
500 N. Brand Blvd., Suite 2100
Glendale, CA 91203
ghunt@brightandbrown.com
Bus. Phone: 818.243.2121

New Member Requests

Tracy Kay Kozlowski
Manager
Stone Cabin Resources, LLC
5 Via Chapala
San Clemente, CA 92673

Transfers

Cecilia E. Rendon
Attorney
Bright and Brown
500 N. Brand Blvd., Suite 2100
TO
Cecilia E. Rendon, Esq, Senior Counsel
Southern California Gas Company
555 West 5th Street, GT14E7
Los Angeles, CA 90013
crendon@socalgas.com
213-244-2082

Chapter President Announces Committee Chairs

Our newly elected Chapter President, Jessica Bradley, RPL, of Warren E & P, Inc. announces her Committee Chairs for the 2019 – 2020 term. The Los Angeles Association of Professional Landmen will be greatly served by the following members:

Legal Counsel	Ernest Guadiana, Esq., Associate, Elkins Kalt Weintraub Reuben Gartside LLP (310) 746-4425 eguadiana@elkinskalt.com
Membership Chair	Allison S. Foster Signal Hill Petroleum (562) 326-5220 AFoster@shpi.net
Website Chair	Chip Hoover, Independent (310) 795-7300 – Cell chiphoover@hotmail.com
Education Chair	Courtney Childress, RPL, President The Mineral Advocate, LLC Office: 866-Landmen Cell: 855-526-3636 courtney.childress@themineraladvocate.com
Publishing/Newsletter Chair	Randall Taylor, RPL, President Taylor Land Services (949) 495-4372 randall@taylorlandservice.com Joseph D. Munsey, RPL, Senior Land Advisor Southern California Gas Company (949) 361-8036 jmunsey@socalgas.com
AAPL Region VIII Director	Randall Taylor, RPL, President Taylor Land Services (949) 495-4372 randall@taylorlandservice.com
Legislative Chair *[By Popular Demand)*	Mike Flores, President Flores Strategies, LLC (310) 990-8657 – Cell mikef@floresstrategies.com
Mickelson Golf Classic Chair	Jason Downs, RPL Senior Land Representative Chevron Pipeline & Power (310) 669-4005 jasondowns@chevron.com
Nominations Chair	TBD

Educational Corner

Courtney Childress, RPL
The Mineral Advocate, LLC
Education Chair

September 2019

Joint Operating Agreements 2-day seminar
When: September 18-19, 2019
Where: Denver, CO
RL/RPL: 14.0
CPL Recertification Credits: 14.0
CPL/ESA Ethics Credits: 0.0

Fundamentals of Land Practices and Optional RPL Exam
When: September 20-21, 2019
Where: Lubbock, TX
RL/RPL: 6.0
CPL Recertification Credits: 6.0
CPL/ESA Ethics Credits: 1.0

Oil and Gas Land Review, CPL/RPL Exam
When: September 24-27, 2019
Where: Casper, WY
RL/RPL: 18.0
CPL Recertification Credits: 18.0
CPL/ESA Ethics Credits: 1.0

RMMLF Institute on Oil & Gas Mineral Title Examination
When: September 25-27, 2019
Where: Westminster, CO
RL/RPL: 0.0
CPL Recertification Credits: 0.0
CPL/ESA Ethics Credits: 0.0

Field Landman Seminar
When: September 26, 2019
Where: Lake Charles, LA
RL/RPL: 3.0
CPL Recertification Credits: 3.0
CPL/ESA Ethics Credits: 0.0

RPL/CPL Exam Only
When: September 27, 2019
Where: Fort Worth, TX
RL/RPL: 0.0
CPL Recertification Credits: 0.0
CPL/ESA Ethics Credits: 0.0

Held by Production and Royalty Issues Seminar
When: September 27, 2019
Where: Fort Worth, TX
RL/RPL: 6.0
CPL Recertification Credits: 6.0
CPL/ESA Ethics Credits: 0.0

October 2019

2019 Appalachian Land Institute*
When: October 3-4, 2019
Where: Coraopolis, PA
RL/RPL: 11.0
CPL Recertification Credits: 11.0
CPL/ESA Ethics Credits: 1.0

Structuring a Deal: Negotiations & Technique Seminar
When: October 8, 2019
Where: San Antonio, TX
RL/RPL: 5.0
CPL Recertification Credits: 5.0
CPL/ESA Ethics Credits: 1.0

Field Landman Seminar
When: October 10, 2019
Where: Oklahoma City, OK
RL/RPL: 3.0
CPL Recertification Credits: 3.0
CPL/ESA Ethics Credits: 0.0

Surface Use and Access*
When: October 15, 2019
Where: Durango, CO
RL/RPL: 5.0
CPL Recertification Credits: 5.0
CPL/ESA Ethics Credits: 1.0

October 2019 continued

Working Interest & NRI Seminar
When: October 17-18, 2019
Where: Fort Worth, TX
RL/RPL: 12.0
CPL Recertification Credits: 12.0
CPL/ESA Ethics Credits: 0.0

2019 Gulf Coast Land Institute*
When: October 17-18, 2019
Where: New Orleans, LA
RL/RPL: 0.0
CPL Recertification Credits: 0.0
CPL/ESA Ethics Credits: 0.0

Surface Use and Access*
When: October 24, 2019
Where: Pittsburgh, PA
RL/RPL: 5.0
CPL Recertification Credits: 5.0
CPL/ESA Ethics Credits: 1.0

RPL/CPL Exam Only
When: October 25, 2019
Where: Forth Worth, TX
RL/RPL: 0.0
CPL Recertification Credits: 0.0
CPL/ESA Ethics Credits: 0.0

November 2019

Advanced Landman's Institute
When: November 7-8, 2019
Where: Houston, TX
RL/RPL: 10.0
CPL Recertification Credits: 10.0
CPL/ESA Ethics Credits: 1.0

Petroleum Economics Seminar*
When: November 8, 2019
Where: Charleston, WV
RL/RPL: 6.0
CPL Recertification Credits: 6.0
CPL/ESA Ethics Credits: 1.0

Joint Operating Agreements Seminar
When: November 14, 2019
Where: Houston, TX
RL/RPL: 7.0
CPL Recertification Credits: 7.0
CPL/ESA Ethics Credits: 0.0

RPL/CPL Exam Only
When: November 15, 2019
Where: Fort Worth, TX
RL/RPL: 0.0
CPL Recertification Credits: 0.0
CPL/ESA Ethics Credits: 0.0

Held by Production and Royalty Issues*
When: November 21, 2019
Where: Washington, PA
RL/RPL: 6.0
CPL Recertification Credits: 6.0
CPL/ESA Ethics Credits: 0.0

December 2019

Due Diligence Seminar*
When: December 5, 2019
Where: Midland, TX
RL/RPL: 5.0
CPL Recertification Credits: 5.0
CPL/ESA Ethics Credits: 0.0

Structuring a deal: Negotiation & Technique Seminar
When: December 6, 2019
Where: Lafayette, LA
RL/RPL: 5.0
CPL Recertification Credits: 5.0
CPL/ESA Ethics Credits: 1.0

December 2019 continued

Oil and Gas Land Review, CPL/RPL Exam
When: December 10-13, 2019
Where: Houston, TX
RL/RPL: 18.0
CPL Recertification Credits: 18.0
CPL/ESA Ethics Credits: 1.0

RPL/CPL Exam Only
When: December 13, 2019
Where: Fort Worth, TX
RL/RPL: 0.0
CPL Recertification Credits: 0.0
CPL/ESA Ethics Credits: 0.0

*Webinar Available

Don't have time to travel for these AAPL seminars/courses but want to further your education? You should consider a Petroleum Land Management Certification. There are several Universities that offer this program and they can be done 100% ONLINE! These programs are self-paced and can be completed in as little as 3 months. I personally took this course from Oklahoma City University in 2014 and found it very informative. Below are some Universities currently offering these programs.

Oklahoma City University- Meinders School of Business
https://www.okcu.edu/business/professional-education/programs/petroleum-land-management/

Metropolitan State University of Denver
https://www.msudenver.edu/plm/

University of Houston-Downtown
http://www.petroleumeducationworkshops.com/university-of-houston-downtown/

AAPL Webinar Series
*All LAAPL members can register and watch these 1 hour webinars but only AAPL member can claim the 1.0 CE Credit

September 19th: Techno Ethics Proceed with Caution
October 17th: The Independent Contractor and You
November 21st: Regulatory Permitting
*Start time for all webinars will be 10:00 AM PST
https://www.landman.org/calendar-and-events/calendar

FREE $50.00 Gift Card GIVEWAY
Courtesy of The Mineral Advocate, LLC

"The Iron Orchard" (available on Amazon Prime) follows the story of Jim McNeeley, an Oil & Gas Wildcatter in the 1940s.

What oil play does McNeeley get his start?

First LAAPL member to email contact@themineraladvocate.com will receive a $50 Gift Card!

Good Luck!

Legislative Update

Mike Flores
Championship Strategies, Inc

LEGISLATIVE SESSION ENDING

Friday, September 13th, was the last day for the state Legislature to pass bills before the legislative session ends. Gov. Gavin Newsom has until October 13th to sign or veto those bills.

- Some of the bills discussed in this legislative update may still change as this update was submitted for publication prior to the legislative deadline of September 13, 2019.
- The article below on AB 5, was taken from the June 2019 LA Magazine article, it provided a simple overview of the complicated bill that, as I write this, still has moving parts.

Bill to Prohibit Drilling of New Leases on Fed Lands Moves Forward

After the Trump administration announced earlier this year that it would open up nearly 1 million acres of federal land in California for oil and gas drilling, which would allow fracking leases, a bill was introduced to prohibit new leases for oil and gas drilling on federal lands. The bill, AB 32, now heads to the desk of Gov. Gavin Newsom for his consideration. This bill is all about California fighting the Trump administration's plan to frack and drill in some of our most beautiful federal protected lands and national monuments," said Assemblyman Al Muratsuchi (D-Rolling Hills Estates), author of the bill. Any new oil or gas projects approved in federally protected areas would be prohibited from having their pipelines or other essential infrastructure cross state lands, under legislation approved by California lawmakers.

Cities Ban Natural Gas from New Building

Berkeley made history in July 2019, becoming the first US city to ban natural gas from new buildings starting in 2020. Menlo Park, California, is now following in its footsteps. The Menlo Park city council decided to ban natural gas in all new commercial, industrial, and high rise apartment buildings within the same timeline (starting in January 2020). The decision is expected to be officially adopted on September 10. Many other cities in the state are considering a similar ban.

AB 1440 Adds Public Health Impact to New Drilling

State officials reviewing new oil or gas drilling permits also will have to consider the effects extraction will have on public health and the environment under a bill heading to the California governor. The California Senate Sept. 3 approved a bill sponsored by the Environmental Working Group and the Natural Resources Defense Council that updates how the state's Division of Oil, Gas, and Geothermal Resources regulates oil and gas. The Assembly approved the bill Sept. 5, clearing the way for the governor to sign or veto.

Study Shows Oil, Natural Gas Generated $152.3B for California's Economy

An article by NATURAL GAS INTELLIGENCE of AUGUST 29, about a study sponsored by the Los Angeles County Economic Development Corp. (LAEDC), reported the oil and natural gas industry activity in California generated $152. 3 billion of economic activity in 2017, representing 2.1% of the state's gross product, according to a statewide study. The study used the most recent annual data, and found that producers generated $21.6 billion in state and local tax revenues, including $96 million in assessments that went to the Department of Conservation's Division of Oil, Gas and Geothermal Resources.

In terms of jobs, wages, tax revenues and contributions to the state economy, the oil and gas sector "makes a significant contribution," said LAEDC Senior Economist Shannon Sedgwick, the lead author of the 160-page report prepared by the Institute for Applied Economics.

Regarding jobs in California, 152,100 are provided directly by the oil and gas industry, and another 365,970 jobs are supported indirectly. Wages in the sector totaled $12 billion, and another $26 billion was paid to workers in the industries supported by oil and gas.

Economic impact statistics are just one part of the continuing story of the oil and gas industry, said Catherine Reheis-Boyd, president of the Western States Petroleum Association (WSPA). The rest has been written by "the state's hard-working men and women who are deeply rooted in the industry and in making their communities thrive," she said.

The LAEDC report reinforces WSPA's arguments against climate change advocates urging the state's leaders to phase out fossil fuel production. WSPA spokesperson Kara Greene added that the report

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underscores the fact that outlawing fossil fuels would have "a tremendous impact on access to energy and the economy, causing a loss of jobs and higher costs from consumers."

The study also found that the average oil and gas job pays more than $80,000 annually. Half of the sectors workers in the state are ethnically diverse, while 63% don't have a college degree and a third have an education level of a high school diploma or less.

AB 5 Could Upend the Gig Economy in California

(Please note this article was taken from a June "LA Magazine" article written by Zoie Matthew and re-publication rights were not obtained.)

What do rideshare drivers, freelancers, and exotic dancers have in common? They're all contract workers, which means they could all be impacted by AB 5, a groundbreaking labor bill that's making its way through the state Senate. Passed by the Assembly last week, the measure would redefine what it means to be an employee in California, extending labor protections and benefits like health care, overtime, and minimum wage to many workers formerly labeled as independent contractors. Here's what you need to know about the bill's background, whom it would affect, and why it might mean the gig is (literally) up in California for app-based companies like Uber and Lyft.

It all started with a court battle last year. AB 5's legal precedent was a 2018 State Supreme Court case involving delivery company Dynamex Operations West. In the case, contract workers at Dynamex argued that because they were required to do things like wear company uniforms and shoulder vehicle costs, they should enjoy the benefits of regular employees. The court ruled unanimously in their favor, coining a procedure called the "ABC" test to help classify workers in future cases.

Assembly Bill 5 would codify that test. If passed, the bill would make "ABC" the standard for determining employment status in California. The three-part gauge mandates that a worker can only be considered a contractor if they are:

1. Free from the "control and direction" of the company they're working for.
2. Performing work that is "outside the course" of the company's usual business.
3. And have their own independently established trade, occupation, or business.

This is far stricter than the current federal determinations for employment status, and would apply to a wide variety of industries. A sizable list of occupations—including doctors, architects, engineers, and independent hair stylists—would be excluded.

App-based employers would have to make some of the biggest changes. Apps like Uber, Lyft, Postmates, and Wag have business models that rely heavily on cutting costs by using independent contractors—a good chunk of their profit margin is made possible because employees take on costs like car maintenance fees and aren't entitled to benefits like sick time or workers' comp. Rideshare drivers for years have been fighting for better treatment from the companies, most recently with a series of worldwide strikes.

If this bill were passed, these "gig economy" heavy hitters would have to start shelling out for employee benefits, which would likely destabilize their business models. This could explain why in recent years that Uber has agreed to settle several multimillion-dollar lawsuits accusing the company of employee misclassification, under the condition that it could keep classifying its workers as freelancers.

Many other industries would be affected, too. In recent years an increasing number of companies have relied on private contractors to drive profits in a strapped labor market; today nearly 36 percent of America's workforce is classified as freelance. Last year contract workers outnumbered direct employees at Google, a trend that is widespread in tech. As media companies have implemented mass layoffs, "full-time freelance" positions that require a 40-hour workweek but lack benefits have become commonplace at magazines, newspapers, and websites. Exotic dancers (who recently launched a labor movement in the wake of the Dynamex ruling), truck drivers, and manicurists are among other careers that could be affected by AB 5.

Even if the bill passes, freelancing (by choice) will still exist. On social media, some have expressed concerns that this bill would make working more difficult for those who prefer to be independent contractors. Lorena González, the San Diego Assembly member who authored AB 5, says she's working to make sure that is not the case. The point, she says, is to protect workers from exploitation and to classify them as real employees with the power to unionize, not to stifle their independence. "We don't want to deny somebody the opportunity to, say, submit a story to The New York Times," she says. "So we are looking at freelancers and working with some of the associations and unions to come up with a definition for what a 'real' freelancer is."

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AB 1328 To Extend Well Abandonment Operations Moves Forward

Existing law requires the owner or operator of a well to file a written notice of intention to commence well abandonment with, and prohibits any abandonment until approval is given by, the State Oil and Gas Supervisor or district deputy. Under existing law, the notice is deemed approved if the supervisor or district deputy fails to respond to the notice in writing within 10 working days from receipt and is deemed canceled if operations have not commenced within one year of receipt.

This bill would extend the time period to commence abandonment operations from one year to 24 months before the notice is deemed canceled.

Under existing law, the Division of Oil, Gas, and Geothermal Resources (DOGGR) in the Department of Conservation regulates the drilling, operation, maintenance, and abandonment of oil and gas wells in the state. Under existing law, any owner or operator, or employee thereof, who refuses to permit the supervisor or the district deputy, or their inspector, to inspect a well, or who willfully hinders or delays the enforcement of provisions relating to the regulation of oil or gas operations, is guilty of a misdemeanor.

This bill would require the division, in consultation with the State Air Resources Board, to initiate a study to be conducted by independent experts of fugitive emissions from idle, idle-deserted, and abandoned wells in the state, as provided. The bill would require oil and gas operators with wells selected for purposes of sampling under these provisions to (1) make reasonable efforts to permit access to the wells to the division and the independent experts contracted to undertake the study if adequate notice is provided to the operator to ensure appropriate safety precautions are taken at the well site, and (2) submit to the division a certification stating that no action was taken to reduce emissions from the sampling site within 72 hours of the sampling taking place so as to reduce the value of measurements taken.

Because a violation of these requirements would be a crime, the bill would impose a state-mandated local program. The bill would require the department, on or before January 1, 2022, to post all results of testing conducted pursuant to the study on the department's internet website in a machine-readable format. The bill would require the department, on or before January 1, 2021, to produce and post an interim progress report describing the status of the study on the department's internet website. The bill would require the independent experts contracted to undertake the study, on or before July 1, 2022, to complete a written document that includes an executive summary of the findings, a description of the results, the findings, and an estimate of hydrocarbon emissions from the state's idle, idle-deserted, and abandoned wells, and would require, before public release, the written document to be provided for peer review and comments, to the operators whose wells were included in the sample, and to a group of independent experts and nongovernmental organizations selected by the division. The bill would require the division, on or before January 1, 2023, to make the results of the study, as per the required written document, available on its internet website.

The California Constitution requires the state to reimburse local agencies and school districts for certain costs mandated by the state. Statutory provisions establish procedures for making that reimbursement. This bill would provide that no reimbursement is required by this act for a specified reason.

MISCELLANEOUS NOTES OF INTEREST:

Morgan Stanley Cuts Price Forecast for Both Brent and WTI

Morgan Stanley cut its crude price forecast for the remainder of 2019, saying that the slowdown in oil demand growth has not ended and the global economic outlook has softened. The bank reduced the Brent price estimate to $60 per barrel from the previous $65, and WTI to $55 from $58. It also said more supply cuts were needed for OPEC to balance the global market.

North Dakota Sets Records for Oil and Gas Production

North Dakota oil drillers set a record for output in June, producing an average of 1.42 million bpd. That bettered the May figure of 1.39 million bpd and passed the previous mark of 1.4 million bpd that was reached in January. The state also hit a new high for natural gas production, 2.87 Bcf/d, up from 2.81 Bcf/d in May.

Case of the Month - Right of Way

Utilities Have the Right to Remove Trees Within an Easement

Brad B. Kuhn, Esq., Partner
Law Firm of Nossaman LLP

Many public agencies and utilities have easements for water or gas pipelines or electric transmission lines. Those easements typically contain express rights to construct, operate, and maintain the facilities, including rights of access; but oftentimes the easements are silent on what rights are reserved to the private property owner, including whether the owner can place trees or other improvements within the easement area. As utilities and public agencies are undertaking more thorough efforts to protect and maintain their rights-of-way, they are commonly seeking to remove such trees and improvements. Absent express language in the easement, are such trees or improvements permitted, or can the agency/utility remove them? A recent Court of Appeal decision, Inzana v. Turlock Irrigation District, provides guidance and indicates the easement holder has the right to remove such trees or improvements upon a showing of reasonable interference.

Background

In Inzana, the Turlock Irrigation District acquired an irrigation easement which granted "a right to construct, maintain, operate, and replace a pipeline and related structures," including "the right to ingress and egress . . . for the purpose of operation, maintaining, repairing, and keeping the pipeline and related structures in operating condition." The property owner subsequently planted pistachio trees within the easement area without notifying TID.

Years later, relying on its own newly enacted internal rules prohibiting the placement of trees or other improvements within its easements, the TID demanded that the property owner remove the pistachio trees, as growing tree roots could eventually impact the pipeline's integrity, causing it to crack and leading to flooding. They stated that if the owner refused to comply, the TID would remove the trees, and the District also threatened to terminate water delivery to the owner's property. The owner filed a lawsuit challenging the TID's removal demand, claiming (i) the easement does not give the TID the right to remove the trees, (ii) the TID's internal rules were not part of the easement and therefore could not be relied upon, and (iii) if the TID removed the trees it would be liable for inverse condemnation for taking private property without paying just compensation. The owner also sought to prevent the TID from terminating water service to the property.

Trial Court Decision

The trial court held that the planting of trees denied the District the right of ingress and egress, and therefore interfered with the District's easement. The court further held that the District had the right to restrict water delivery to the property.

The Appeal

The Court of Appeal agreed. The Court provided a general background on easement rights, explaining:

> "The rights and duties between the owner of an easement and the owner of the servient tenement . . . are correlative. Each is required to respect the rights of the other. Neither party can conduct activities or place obstructions on the property that unreasonably interfere with the other party's use of the property. In this respect, there are no absolute rules of conduct. The responsibility of each party to the other and the "reasonableness" of use of the property depends on the nature of the easement, its method of creation, and the facts and circumstances surrounding the transaction."

The Court further explained:

> "[a property owner is] entitled to make all uses of the land that are not prohibited by the servitude and that do not interfere unreasonably with the uses authorized by the easement. . . . Actions that make it more difficult to use an easement, that interfere with the ability to maintain and repair improvements built for its enjoyment, or that increase the risks attendant on exercise of rights created

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by the easement are prohibited . . . . In determining whether the holder of the servient estate has unreasonably interfered with exercise of an easement, the interests of the parties must be balanced to strike a reasonable accommodation that maximizes overall utility to the extent consistent with effectuating the purpose of the easement . . . ."

Applied to this situation, the Court explained that the evidence showed that the trees interfered with the District's ability to maintain and repair the pipeline; and could eventually cause a maintenance issue or damage the pipeline. As a result, the District could require the removal of the trees pursuant to its easement rights, and it would not be liable for a taking.

With respect to the District's termination of water delivery to the property, the Court explained that irrigation districts are statutorily granted the power to create equitable rules for the distribution and use of water, and a district's ability to enforce rules by terminating water delivery is a tool in providing for the orderly distribution of irrigation water. The court therefore held that there is nothing inequitable in refusing to deliver water to landowners who refuse to comply with the district's rules.

Conclusion

The Inzana decision is an important reminder for public agencies and utilities that their typical pipeline or transmission line easements include the right to prevent the placement of trees (or other improvements) within their easements to the extent such improvements interfere with the ability to access, maintain, operate, or repair the facilities; express easement language on this topic is not necessarily required. The decision is also important for property owners, as they need to understand that in granting easement rights on their property, there is a likelihood that their remaining use of the easement area can be significantly limited, even if not expressly called out in the easement document.

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Not Your Average Lessor: The False Claims Act and Treble Damages in Royalty Disputes with the Federal Government

By Thomas C. Ryan, Esq., Partner, Jamie Lavergne Bryan, Esq., Partner, Katherine M. Gafner, Esq., Associate, Jared A. Kephart, Esq., Partner, & Raymond E. Yammine, Esq., Associate, of K & L Gates





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Introduction

On May 1, 2019, the U.S. Department of Justice ("DOJ") and the U.S. Attorney's Office ("USAO") for the Northern District of Texas announced a $4.375 million civil settlement with a natural gas marketer and three individuals over alleged royalty fraud against the federal government in violation of the False Claims Act ("FCA").[1] Historically, FCA actions are uncommon in the energy sector, but this marks the second such settlement in the past 18 months. In December 2017, DOJ announced a $2.25 million FCA settlement with a gas producer related to the alleged underpayment of "royalties owed on natural gas produced from federal lands."[2] Strikingly, the settlements involved states—Texas and Colorado—that are generally viewed as friendly to the oil and gas industry. Against the backdrop of the Trump administration's efforts to lease more federal lands for oil and gas exploration, these actions may be a harbinger of additional enforcement to come, and energy companies that seize on the opportunities that federal lands offer should be wise to the potential liabilities (including treble damages plus penalties) arising out of a violation of the FCA.

B. Charles Rogers Gas Ltd. – Northern District of Texas (2019)

In the most recent action, the USAO for the Northern District of Texas alleged that natural gas marketer B. Charles Rogers Gas Ltd. ("BCR")—which marketed hydrocarbons for extraction companies operating on land leased from the U.S. Department of the Interior ("DOI") and the Bureau of Land Management ("BLM")—and three associated individuals had issued false transaction statements to producers, underreporting "the volume and value" of purchased liquid natural gas.[3] Because lessees are in turn responsible for informing DOI how much is owed in royalties, according to DOJ, this led to the underpayment of royalties by the producers, including royalties due to the federal landowners. Because BCR's alleged false statements caused an underpayment of royalties owed to the federal government, DOJ was able to leverage the FCA's treble damages hammer and ultimately obtain a total settlement of $4.375 million.[4]

Citation Oil & Gas – District of Colorado (2017)

Though BCR is a marketer, the same theory has been previously directly applied to oil and gas producers. In December 2017, DOJ and the USAO for the District of Colorado entered a settlement with Citation Oil & Gas ("Citation") in which Citation agreed to pay $2.25 million to settle claims that it violated the FCA by "underpa[ying] royalties owed on natural gas produced from federal lands" in Wyoming by taking improper deductions.[5] More specifically, DOJ alleged

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that Citation "knowingly deducted[,] from royalty values[,] fees paid to other companies that included the cost of placing the gas in marketable condition"[6] despite such costs being specifically excluded from allowable royalty deductions in the federal leasing program.

The False Claims Act and Reverse False Claims

Oil and gas companies are no strangers to royalty and lease disputes, but when the lessee is the federal government, what starts as a royalty dispute involving simple compensatory damages can quickly morph into an enforcement action pursuant to the FCA, introducing the possibility of treble damages plus $5,500 to $11,000 in per-claim penalties (which can add up quickly depending on how a court defines a "claim").

The primary provisions of the FCA, sections 3729(a)(1)(A) and (B), create civil liability for any person who knowingly submits a false claim to the government or causes another to submit a false claim to the government or knowingly makes a false record or statement to get a false claim paid by the government. These provisions have not been widely applied in the context of the oil and gas industry (likely because oil and gas production and marketing companies are not generally making sales to the government), but § 3729(a)(1)(G) provides for liability for "reverse false claims"—or making false statements to the government to avoid having to pay money to the government or to improperly limit the amount of money owed. The claims against BCR and Citation were predicated on this "reverse false claim" theory: that BCR and Citation both were alleged to have knowingly made materially false statements to the government to limit what would be owed.

Notably, as demonstrated in the BCR settlement, the FCA includes "causing" another to make a false claim (or reverse false claim) and so the payment need not be direct. Accordingly, companies cannot assume they do not have any FCA risk simply because they make no direct payments to the federal government. In other words, liability could conceivably trickle down to companies engaged in joint operating agreements.

More Federal Leases Means More Potential Exposure

Historically, this has been a relatively minor concern, as FCA claims are not common in the oil and gas industry.[7] In recent years, however, the Trump administration has actively pursued efforts to lease out additional federal lands for development, resulting in the DOI setting an all-time record for oil and gas lease sales generating more than $1.1 billion in revenue in 2018.[8] This expanding opportunity comes with expanded risk as more and more lease and royalty payments are directed towards federal coffers and more and more payors are subject to potential FCA liability. The risk is particularly significant for companies operating in or buying from Wyoming, New Mexico, Colorado, Utah, Montana, and Alaska, each of which has more than one million federally owned acres currently under lease (Wyoming tops the list with more than eight million).[9] All told, 32 states had some federally owned lands under lease on the last day of FY2018, so risk exists even outside of these states.

As such, the oil and gas industry should continue to monitor the federal government's use of the FCA as an enforcement tool in this area and may wish to conduct a risk assessment of its own operations to ensure its payment programs are accurate and determine what, if any, of its payments are ultimately directed towards the federal government to fully understand the level of risk.

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[1] U.S. Dep't of Justice, Gas Marketer B. Charles Rogers Gas and Three Individuals Agree to Pay $4.375 Million to Resolve Royalty Fraud Allegations (May 1, 2019), https://www.justice.gov/opa/pr/gas-marketer-b-charles-rogers-gas-and-three-individuals-agree-pay-4375-million-resolve.

[2] U.S. Dep't of Justice, Citation Companies Agree to Pay $2.25 Million to Settle Civil False Claims Act Allegations (Dec. 19, 2017), https://www.justice.gov/opa/pr/citation-companies-agree-pay-225-million-settle-civil-false-claims-act-allegations/.

[3] U.S. Dep't of Justice, Gas Marketer B. Charles Rogers Gas and Three Individuals Agree to Pay $4.375 Million to Resolve Royalty Fraud Allegations (May 1, 2019), https://www.justice.gov/opa/pr/gas-marketer-b-charles-rogers-gas-and-three-individuals-agree-pay-4375-million-resolve.

[4] Id.

[5] U.S. Dep't of Justice, Citation Companies Agree to Pay $2.25 Million to Settle Civil False Claims Act Allegations (Dec. 19, 2017), https://www.justice.gov/opa/pr/citation-companies-agree-pay-225-million-settle-civil-false-claims-act-allegations/.

[6] Id.

[7] They are not, however, unknown. From 2009–2012, 13 oil and gas companies paid a total of $146.7 million in settlements to resolve FCA allegations that "the companies knowingly underpaid royalties for gas extracted from federal and Indian lands." U.S. Dep't of Justice, Fact Sheet Significant False Claims Act Settlements & Judgments Fiscal Years 2009–2016 (2017), https://www.justice.gov/opa/press-release/file/918366/download.

[8] James Osborne, Sale of oil leases on federal lands earns record $1.1B, encroaching on 'sensitive' areas (Feb. 18, 2019), https://www.houstonchronicle.com/business/energy/article/Trump-looks-to-sensitive-public-lands-in-13624072.php.

[9] See Bureau of Land Mgmt., Oil and Gas Statistics (May 2019), https://www.blm.gov/programs/energy-and-minerals/oil-and-gas/oil-and-gas-statistics.

Guest Article

Why Resources Aren't 'Natural' and Will Never Run Out

By Steve Goreham

Originally published in The Washington Times*, Republished with Permission*

Aluminum Ore (Bauxite), Image by Saphon — Aluminum, Image by Image of Elements

Ed. Note: Mr. Goreham is the Executive Director of the Climate Science Coalition of America, a non-political association of scientists, engineers, and citizens dedicated to informing Americans about the realities of climate science and energy economics.

Last week, the World Wildlife Fund proclaimed May 10 to be Europe's "Overshoot Day," the day that Europe consumed its portion of Earth's resources for the year. The WWF, the United Nations, and universities continue to warn that modern society is rapidly depleting our natural resources. But instead, trends show that for all practical purposes, Earth's resources will never run out.

The World Wildlife Fund proclaims August 1 this year as Earth Overshoot Day, where society will have used "more natural resources than the planet is able to produce in a 12-month period." They estimate that Overshoot Day for the United States occurred already in March, warning that the US is using four times its share of sustainable global resources.

Overshoot Day is a continuation of the long-running ideology that humans are consuming too much of Earth's resources. Environmentalist David Suzuki said, "We live in a world of finite resources. Although it may sometimes seem quite big, Earth is really very small—a tiny blue and green oasis of life in a cold universe." Margaret Beckett, UK Environment Secretary pointed out in 2006, "It is a stark and arresting fact that, since the middle of the 20th century, humankind has consumed more natural resources than in all previous human history."

Price trends are usually a good indicator of resource scarcity. The World Bank maintains a world commodity price database of 41 commodities from 1960 to present. Inflation-adjusted trends show that from 1960-2015, food prices have declined, agricultural raw material and industrial metal prices have been flat, and energy prices, dominated by the price of oil, have increased. Commodity prices fluctuate widely from decade to decade, but we don't see a rising price trend indicating resource exhaustion.

The 1972 international best-selling book Limits to Growth predicted humanity would run out of aluminum by 2027, copper by 2020, gold by 2001, lead by 2036, mercury by 2013, silver by 2014, and zinc by 2022. But today, none of these metals is in historically short supply.

Global production of industrial metals soared from 1960-2014. Annual production levels were up: aluminum (996 percent), copper (417 percent), iron ore (531 percent), lead (343 percent), nickel (455 percent), tin (66 percent), and zinc (348 percent). At the same time, the World Bank industrial metal real price index of these seven metals was flat, down a little more than one percent by 2015. World reserves of copper, iron ore, lead, and zinc stand near all-time highs. Prices are not rising as predicted by resource-depletion pessimists.

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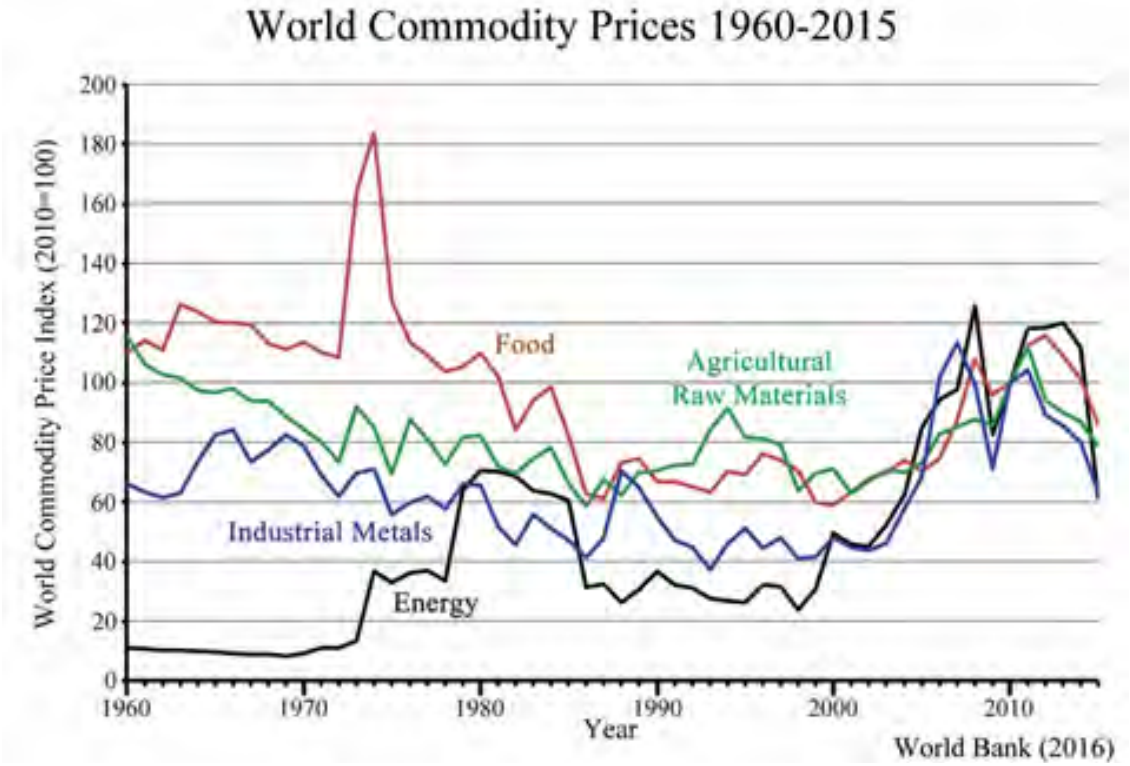

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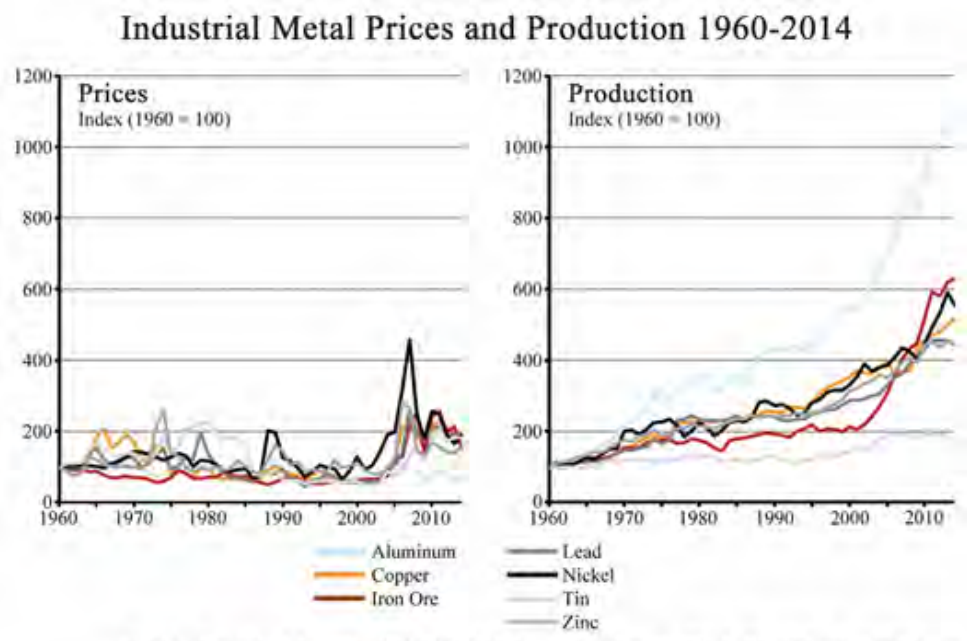
"Natural resources" is a misleading label. The term "natural resources" conveys the naive idea that food, energy, or materials can merely be plucked from a tree or gathered from a field or stream. Raw materials are natural, but resources are created by humans from raw materials.

Consider the miracle of copper refining. Rock containing copper is fragmented by explosions and then loaded onto huge trucks with 240-ton capacity. Each ton of rock contains only 13 pounds of copper. The copper ore then goes through a series of milling machines that grind the rock down to a fine powder. Next the powder goes through a flotation cell, where the copper floats to the top of a solution and is skimmed off, producing 28 percent copper concentrate. Three different furnaces come next, smelting the metal into 98 percent copper. Finally, electrolysis is used in a half-mile-long factory to produce ingots that are 99.99 percent copper. Advancing human technology continues to produce high-quality copper from ores of declining copper concentration.

But aren't we running out of raw materials to make copper metal and other resources? Most people don't realize the vast quantity of raw materials available on our planet. Canadian geologist David Brooks estimated that a single average cubic mile of Earth's crust contains a billion tons of aluminum (from bauxite), over 500 million tons of iron, a million tons of zinc and 600,000 tons of copper.

There are 57 million such square miles of Earth's land surface and almost triple that area under the surface of the oceans. Of course, only a tiny fraction of metals in Earth's crust is economically recoverable with today's technology. Nevertheless, Earth's supply of raw materials is finite, but vast.



British Geological Survey, 1960-2013; US Geological Survey, 2015; World Bank, 1960-2014

But aren't we running out of hydrocarbon energy? In 1977, President Jimmy Carter told the nation, "World consumption of oil is still going up. If it were possible to keep it rising during the 1970s and 1980s …we could use up all the proven reserves of oil in the entire world by the end of the next decade."

President Carter and his advisors were wrong. Petroleum engineers changed the world with the technological advances of hydraulic fracturing and horizontal drilling. United States daily oil production more than doubled from 5 million barrels in 2008 to over 12 million barrels today. US natural gas production also doubled over the last decade.

From 1980-2017 world petroleum production increased more than 50 percent. But world crude oil reserves increased 150 percent, from 27 years of supply to 46 years of supply at higher production rates. The same doomsayers that continue to forecast resource depletion were certain we had reached peak oil a decade ago.

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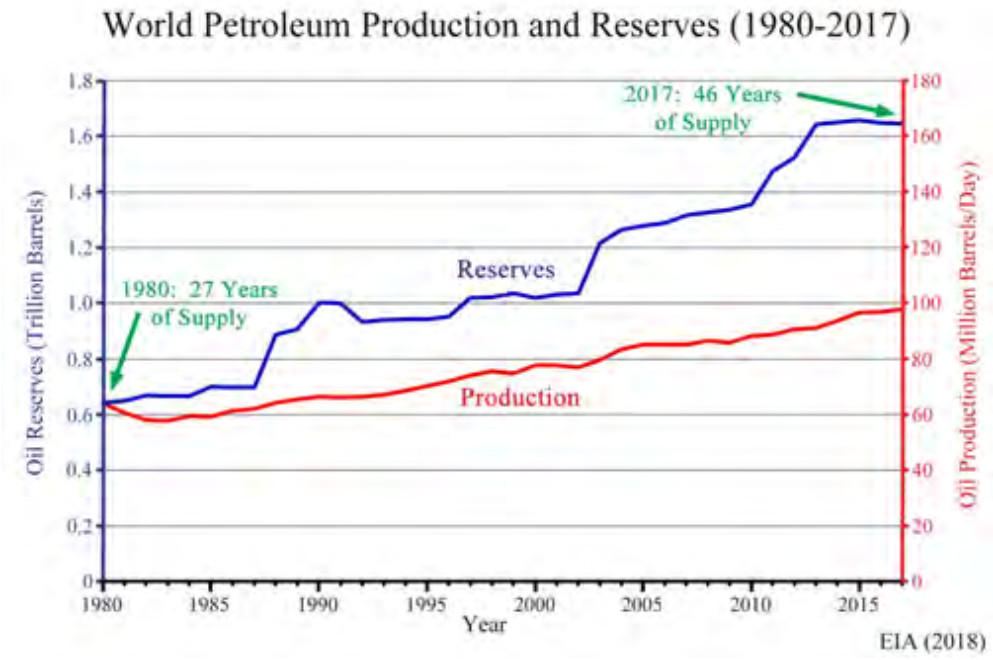

Today, humanity has the greatest abundance of resources in history. Human ingenuity determines resource availability, not the amount of fruit on a tree or the number of rocks on the ground. Driven by advancing human technology, for all practical purposes, Earth's resources will never run out.

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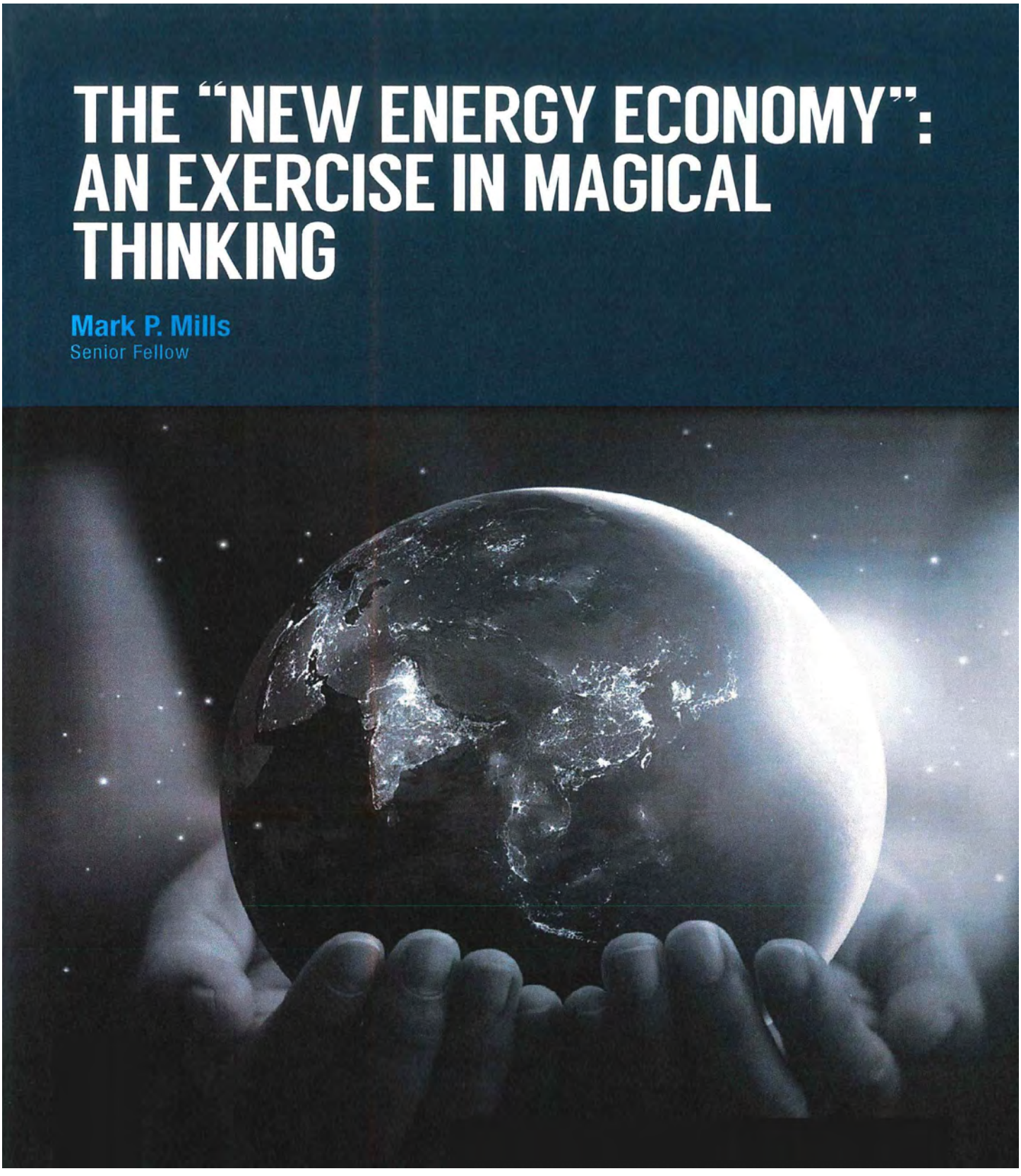
The "New Energy Economy": An Exercise in Magical thinking

~Mark P. Mills, Senior Fellow~



About the Author

Mark P. Mills is a senior fellow at the Manhattan Institute and a faculty fellow at Northwestern University's McCormick School of Engineering and Applied Science, where he co-directs an Institute on Manufacturing Science and Innovation. He is also a strategic partner with Cottonwood Venture Partners (an energy-tech venture fund). Previously, Mills cofounded Digital Power Capital, a boutique venture fund, and was chairman and CTO of ICx Technologies, helping take it public in 2007. Mills is a regular contributor to Forbes.com and is author of *Work in the Age of Robots* (2018). He is also coauthor of *The Bottomless Well: The Twilight of Fuel, the Virtue of Waste, and Why We Will Never Run Out of Energy* (2005). His articles have been published in the *Wall Street Journal*, *USA Today*, and Real Clear. Mills has appeared as a guest on CNN, Fox, NBC, PBS, and The Daily Show with Jon Stewart. In 2016, Mills was named "Energy Writer of the Year" by the American Energy Society.

Earlier, Mills was a technology advisor for Bank of America Securities and coauthor of the *Huber-Mills Digital Power Report*, a tech investment newsletter. He has testified before Congress and briefed numerous state public-service commissions and legislators. Mills served in the White House Science Office under President Reagan and subsequently provided science and technology policy counsel to numerous private-sector firms, the Department of Energy, and U.S. research laboratories.

Early in his career, Mills was an experimental physicist and development engineer at Bell Northern Research (Canada's Bell Labs) and at the RCA David Sarnoff Research Center on microprocessors, fiber optics, missile guidance, earning several patents for his work. He holds a degree in physics from Queen's University in Ontario, Canada.

Executive Summary

A movement has been growing for decades to replace hydrocarbons, which collectively supply 84% of the world's energy. It began with the fear that we were running out of oil. That fear has since migrated to the belief that, because of climate change and other environmental concerns, society can no longer tolerate burning oil, natural gas, and coal—all of which have turned out to be abundant.

So far, wind, solar, and batteries—the favored alternatives to hydrocarbons—provide about 2% of the world's energy and 3% of America's. Nonetheless, a bold new claim has gained popularity: that we're on the cusp of a tech-driven energy revolution that not only can, but inevitably will, rapidly replace all hydrocarbons.

This "new energy economy" rests on the belief—a centerpiece of the Green New Deal and other similar proposals both here and in Europe—that the technologies of wind and solar power and battery storage are undergoing the kind of disruption experienced in computing and communications, dramatically lowering costs and increasing efficiency. But this core analogy glosses over profound differences, grounded in physics, between systems that produce energy and those that produce information.

In the world of people, cars, planes, and factories, increases in consumption, speed, or carrying capacity cause hardware to expand, not shrink. The energy needed to move a ton of people, heat a ton of steel or silicon, or grow a ton of food is determined by properties of nature whose boundaries are set by laws of gravity, inertia, friction, mass, and thermodynamics—not clever software.

This paper highlights the physics of energy to illustrate why there is no possibility that the world is undergoing—or can undergo—a near-term transition to a "new energy economy."

Among the reasons:

- Scientists have yet to discover, and entrepreneurs have yet to invent, anything as remarkable as hydrocarbons in terms of the combination of low-cost, high-energy density, stability, safety, and portability. In practical terms, this means that spending $1 million on utility-scale wind turbines, or solar panels will each, over 30 years of operation, produce about 50 million kilowatt-hours (kWh)—while an equivalent $1 million spent on a shale rig produces enough natural gas over 30 years to generate over 300 million kWh.

- Solar technologies have improved greatly and will continue to become cheaper and more efficient. But the era of 10-fold gains is over. The physics boundary for silicon photovoltaic (PV) cells, the Shockley-Queisser Limit, is a maximum conversion of 34% of photons into electrons; the best commercial PV technology today exceeds 26%.

- Wind power technology has also improved greatly, but here, too, no 10-fold gains are left. The physics boundary for a wind turbine, the Betz Limit, is a maximum capture of 60% of kinetic energy in moving air; commercial turbines today exceed 40%.

- The annual output of Tesla's Gigafactory, the world's largest battery factory, could store three minutes' worth of annual U.S. electricity demand. It would require 1,000 years of production to make enough batteries for two days' worth of U.S. electricity demand. Meanwhile, 50–100 pounds of materials are mined, moved, and processed for every pound of battery produced.

THE "NEW ENERGY ECONOMY": AN EXERCISE IN MAGICAL THINKING

Introduction

A growing chorus of voices is exhorting the public, as well as government policymakers, to embrace the necessity—indeed, the inevitability—of society's transition to a "new energy economy." (See sidebar, **Peak Hydrocarbons Just Around the Corner**.) Advocates claim that rapid technological changes are becoming so disruptive and renewable energy is becoming so cheap and so fast that there is no economic risk in accelerating the move to—or even mandating—a post-hydrocarbon world that no longer needs to use much, if any, oil, natural gas, or coal.

Central to that worldview is the proposition that the energy sector is undergoing the same kind of technology disruptions that Silicon Valley tech has brought to so many other markets. Indeed, "old economy" energy companies are a poor choice for investors, according to proponents of the new energy economy, because the assets of hydrocarbon companies will soon become worthless, or "stranded."[1] Betting on hydrocarbon companies today is like betting on Sears instead of Amazon a decade ago.

"Mission Possible," a 2018 report by an international Energy Transitions Commission, crystallized this growing body of opinion on both sides of the Atlantic.[2] To "decarbonize" energy use, the report calls for the world to engage in three "complementary" actions: aggressively deploy renewables or so-called clean tech, improve energy efficiency, and limit energy demand.

This prescription should sound familiar, as it is identical to a nearly universal energy-policy consensus that coalesced following the 1973–74 Arab oil embargo that shocked the world. But while the past half-century's energy policies were animated by fears of resource depletion, the fear now is that burning the world's abundant hydrocarbons releases dangerous amounts of carbon dioxide into the atmosphere.

To be sure, history shows that grand energy transitions are possible. The key question today is whether the world is on the cusp of another.

The short answer is no. There are two core flaws with the thesis that the world can soon abandon hydrocarbons. The first: physics realities do not allow energy domains to undergo the kind of revolutionary change experienced on the digital frontiers. The second: no fundamentally new energy technology has been discovered or invented in nearly a century—certainly, nothing analogous to the invention of the transistor or the Internet.

Before these flaws are explained, it is best to understand the contours of today's hydrocarbon-based energy economy and why replacing it would be a monumental, if not an impossible, undertaking.

Moonshot Policies and the Challenge of Scale

The universe is awash in energy. For humanity, the challenge has always been to deliver energy in a useful way that is both tolerable and available when it is needed, not when nature or luck offers it. Whether it be wind or water on the surface, sunlight from above, or hydrocarbons buried deep in the earth, converting an energy

Peak Hydrocarbons Just Around the Corner

"[Clean tech is] a perfect example of a 10x exponential process which will wipe fossil fuels off the market in about a decade."
—TONY SEBA, STANFORD ECONOMIST

"Until now, observers mostly paid attention to the likely effectiveness of climate policies, but not to the ongoing and effectively irreversible technological [energy] transition."
— JEAN-FRANÇOIS MERCURE, CAMBRIDGE UNIVERSITY

"[By] 2030, the cost [of solar] could be so near to zero it will effectively be free."
— SAM ARIE, UBS RESEARCH ANALYST

"The world is experiencing a global energy transformation driven by technological change and new policy priorities."
— EUROPEAN UNION, MISSION POSSIBLE REPORT FOR THE G20

"Global shift to clean energy is under way, but much more needs to be done."
— LETTER TO G7 SUMMIT BY 288 OF THE WORLD'S LARGEST INVESTORS

"A carbon tax should increase every year until emissions reductions goals are met [which] ... will encourage [carbon-free] technological innovation and large-scale infrastructure development."
— BAKER-SHULTZ PLAN, SIGNED BY ECONOMISTS, NOBELISTS, FED RESERVE CHAIRS, ETC.

"Green technologies, like batteries and solar and wind power, are improving far faster than many realize ... [It's] *the biggest reshuffling of the economy since the Industrial Revolution."*
— JEREMY GRANTHAM, INVESTOR, BILLIONAIRE

"Smartphone substitution seemed no more imminent in the early 2000s than large-scale energy substitution seems today."
— INTERNATIONAL MONETARY FUND

Source: Tony Seba, "Clean Disruption" (video), Stanford University, 2017; Jean-François Mercure quoted in Steve Hanley, "Carbon Bubble About to Burst, Leaving Trillions in Stranded Assets Behind, Claims New Research," Clean Technica, June 5, 2018; Sam Arie, "Renewables Are Primed to Enter the Global Energy Race," *Financial Times*, Aug. 13, 2018; OECD, "Mission Possible," Energy Transitions Commission, November 2018; Steve Hanley, "Ahead of G7 Meeting, Investors Urge an End to Coal Power & Fossil Fuel Subsidies," Clean Technica, June 5, 2018; "Economists' Statement on Carbon Dividends; "Investing Prophet Jeremy Grantham Takes Aim at Climate Change," Bloomberg, Jan. 17, 2019; *Wall Street Journal*, Jan. 16, 2019 (Baker-Shultz plan); International Monetary Fund, "Riding the Energy Transition: Oil Beyond 2040," May 2017

source into useful power always requires capital-intensive hardware.

Considering the world's population and the size of modern economies, scale matters. In physics, when attempting to change any system, one has to deal with inertia and various forces of resistance; it's far harder to turn or stop a Boeing than it is a bumblebee. In a social system, it's far more difficult to change the direction of a country than it is a local community.

Today's reality: hydrocarbons—oil, natural gas, and coal—supply 84% of global energy, a share that has decreased only modestly from 87% two decades ago (**Figure 1**).[3] Over those two decades, total world energy use rose by 50%, an amount equal to adding two entire United States' worth of demand.[4]

The small percentage-point decline in the hydrocarbon share of world energy use required over $2 trillion in cumulative global spending on alternatives over that period.[5] Popular visuals of fields festooned with windmills and rooftops laden with solar cells don't change the fact that these two energy sources today provide less than 2% of the global energy supply and 3% of the U.S. energy supply.

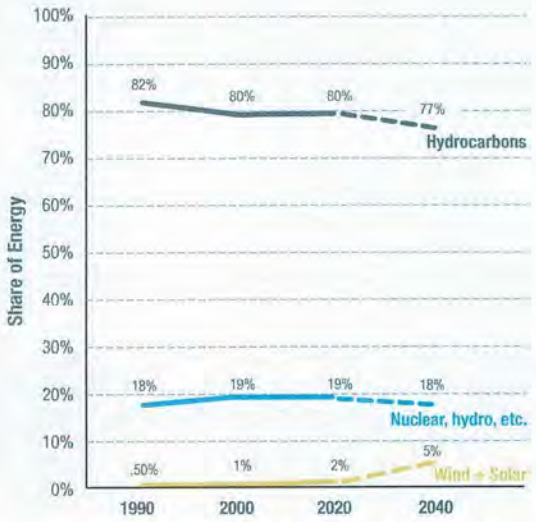
The scale challenge for any energy resource transformation begins with a description. Today, the world's economies require an annual production of 35 billion barrels of petroleum, plus the energy equivalent of another 30 billion barrels of oil from natural gas, plus the energy equivalent of yet another 28 billion barrels of oil from coal. In visual terms: if all that fuel were in the form of oil, the barrels would form a line from Washington, D.C., to Los Angeles, and that entire line would increase in height by one Washington Monument every week.

To completely replace hydrocarbons over the next 20 years, global renewable energy production would have to increase by at least 90-fold.[6] For context: it took a half-century for global oil and gas production to expand by 10-fold.[7] It is a fantasy to think, costs aside, that any new form of energy infrastructure could now expand nine times more than that in under half the time.

If the initial goal were more modest—say, to replace hydrocarbons only in the U.S. and only those used in electricity generation—the project would require an industrial effort greater than a World War II–level of mobilization.[8] A transition to 100% non-hydrocarbon *electricity* by 2050 would require a U.S. grid construction program 14-fold bigger than the grid build-out rate that has taken place over the past half-century.[9] Then, to finish the transformation, this Promethean

FIGURE 1.

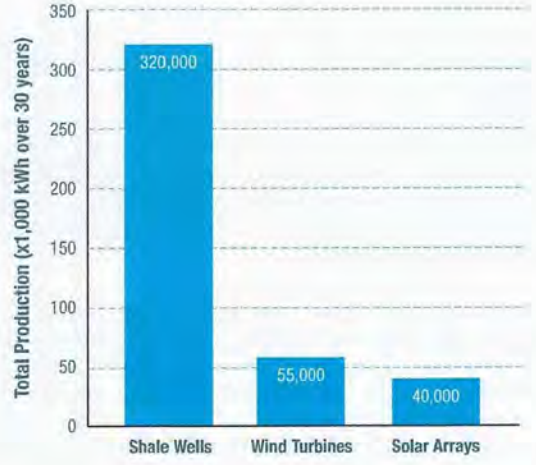
How the World Is Fueled



Source: ExxonMobil, "2018 Outlook for Energy: A View to 2040"; Energy Information Agency (EIA), "International Energy Statistics"

FIGURE 2.

Total 30-Year Electricity Production from $1 Million in Hardware: Wind Turbines, Solar Arrays, and Shale Wells



Source: Lazard, "Lazard's Levelized Cost of Energy Analysis," 2018; Gulfport Energy, Credit Suisse Energy Summit, 2019; Cabot Oil & Gas, Heikkinen Energy Conference, Aug. 15, 2018

effort would need to be more than doubled to tackle nonelectric sectors, where 70% of U.S. hydrocarbons are consumed. And all that would affect a mere 16% of world energy use, America's share.

This daunting challenge elicits a common response: "If we can put a man on the moon, surely we can [fill in the blank with any aspirational goal]." But transforming the energy economy is not like putting a few people on the moon a few times. It is like putting all of humanity on the moon—permanently.

The Physics-Driven Cost Realities of Wind and Solar

The technologies that frame the new energy economy vision distill to just three things: windmills, solar panels, and batteries.[10] While batteries don't produce energy, they are crucial for ensuring that episodic wind and solar power is available for use in homes, businesses, and transportation.

Yet windmills and solar power are themselves not "new" sources of energy. The modern wind turbine appeared 50 years ago and was made possible by new materials, especially hydrocarbon-based fiberglass. The first commercially viable solar tech also dates back a half-century, as did the invention of the lithium battery (by an Exxon researcher).[11]

Over the decades, all three technologies have greatly improved and become roughly 10-fold cheaper.[12] Subsidies aside, that fact explains why, in recent decades, the use of wind/solar has expanded so much from a base of essentially zero.

Nonetheless, wind, solar, and battery tech will continue to become better, within limits. Those limits matter a great deal—about which, more later—because of the overwhelming demand for power in the modern world and the realities of energy sources on offer from Mother Nature.

With today's technology, $1 million worth of utility-scale solar panels will produce about 40 million kilowatt-hours (kWh) over a 30-year operating period (**Figure 2**). A similar metric is true for wind: $1 million worth of a modern wind turbine produces 55 million kWh over the same 30 years.[13] Meanwhile, $1 million worth of hardware for a shale rig will produce enough natural gas over 30 years to generate over 300 million

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kWh.[14] That constitutes about 600% more electricity for the same capital spent on primary energy-producing hardware.[15]

The fundamental differences between these energy resources can also be illustrated in terms of individual equipment. For the cost to drill a single shale well, one can build two 500-foot-high, 2-megawatt (MW) wind turbines. Those two wind turbines produce a combined output averaging over the years to the energy equivalent of 0.7 barrels of oil per hour. The same money spent on a single shale rig produces 10 barrels of oil, per hour, or its energy equivalent in natural gas, averaged over the decades.[16]

The huge disparity in output arises from the inherent differences in energy densities that are features of nature immune to public aspiration or government subsidy. The high energy density of the physical chemistry of hydrocarbons is unique and well understood, as is the science underlying the low energy density inherent in surface sunlight, wind volumes, and velocity.[17] *Regardless of what governments dictate that utilities pay for that output, the quantity of energy produced is determined by how much sunlight or wind is available over any period of time and the physics of the conversion efficiencies of photovoltaic cells or wind turbines.*

These kinds of comparisons between wind, solar, and natural gas illustrate the starting point in making a raw energy resource useful. But for any form of energy to become a primary source of power, additional technology is required. For gas, one necessarily spends money on a turbo-generator to convert the fuel into grid electricity. For wind/solar, spending is required for some form of storage to convert episodic electricity into utility-grade, 24/7 power.

The high cost of ensuring energy availability

Availability is the single most critical feature of any energy infrastructure, followed by price, followed by the eternal search for decreasing costs without affecting availability. Until the modern energy era, economic and social progress had been hobbled by the episodic nature of energy availability. That's why, so far, more than 90% of America's electricity, and 99% of the power used in transportation, comes from sources that can easily supply energy any time on demand.[18]

In our data-centric, increasingly electrified, society, always-available power is vital. But, as with all things, physics constrains the technologies and the costs for supplying availability.[19] For hydrocarbon-based systems, availability is dominated by the cost of equipment that can convert fuel-to-power continuously for at least 8,000 hours a year, for decades. Meanwhile, it's inherently easy to store the associated fuel to meet expected or unexpected surges in demand, or delivery failures in the supply chain caused by weather or accidents.

It costs less than $1 a barrel to store oil or natural gas (in oil-energy equivalent terms) for a couple of months.[20] Storing coal is even cheaper. Thus, unsurprisingly, the U.S., on average, has about one to two *months'* worth of national demand in storage for each kind of hydrocarbon at any given time.[21]

Meanwhile, with batteries, it costs roughly $200 to store the energy equivalent to one barrel of oil.[22] Thus, instead of months, barely two *hours* of national electricity demand can be stored in the combined total of all the utility-scale batteries on the grid plus all the batteries in the 1 million electric cars that exist today in America.[23]

For wind/solar, the features that dominate cost of availability are inverted, compared with hydrocarbons. While solar arrays and wind turbines do wear out and require maintenance as well, the physics and thus additional costs of that wear-and-tear are less challenging than with combustion turbines. But the complex and comparatively unstable electrochemistry of batteries makes for an inherently more expensive and less efficient way to store energy and ensure its availability.

Since hydrocarbons are so easily stored, idle conventional power plants can be dispatched—ramped up and down—to follow cyclical demand for electricity. Wind turbines and solar arrays cannot be dispatched when there's no wind or sun. As a matter of geophysics, both wind-powered and sunlight-energized machines produce energy, averaged over a year, about 25%–30% of the time, often less.[24] Conventional power plants, however, have very high "availability," in the 80%–95% range, and often higher.[25]

A wind/solar grid would need to be sized to meet both peak demand *and* to have enough extra capacity beyond peak needs in order to produce and store additional electricity when sun and wind are available. This means, on average, that a pure wind/solar system would necessarily have to be about threefold the capacity of a hydrocarbon grid: i.e., one needs to build 3 kW of wind/solar equipment for every 1 kW of combustion equipment eliminated. That directly translates into a threefold cost disadvantage, even if the per-kW costs were all the same.[26]

Even this necessary extra capacity would not suffice. Meteorological and operating data show that average monthly wind and solar electricity output can drop as much as twofold during each source's respective "low" season.[27]

The myth of grid parity

How do these capacity and cost disadvantages square with claims that wind and solar *are already* at or near "grid parity" with conventional sources of electricity? The U.S. Energy Information Agency (EIA) and other similar analyses report a "levelized cost of energy" (LCOE) for all types of electric power technologies. In the EIA's LCOE calculations, electricity from a wind turbine or solar array is calculated as 36% and 46%, respectively, more expensive than from a natural-gas turbine—i.e., approaching parity.[28] But in a critical and rarely noted caveat, EIA states: "The LCOE values for dispatchable and non-dispatchable technologies are listed separately in the tables because comparing them *must be done carefully*"[29] (emphasis added). Put differently, the LCOE calculations do not take into account the array of real, if hidden, costs needed to operate a reliable 24/7 and 365-day-per-year energy infrastructure—or, in particular, a grid that used only wind/solar.

The LCOE considers the hardware in isolation while ignoring real-world system costs essential to supply 24/7 power. Equally misleading, an LCOE calculation, despite its illusion of precision, relies on a variety of assumptions and guesses subject to dispute, if not bias.

For example, an LCOE assumes that the future cost of competing fuels—notably, natural gas—will rise significantly. But that means that the LCOE is more of a forecast than a calculation. This is important because a "levelized cost" uses such a forecast to calculate a purported average cost over a long period. The assumption that gas prices will go up is at variance with the fact that they have decreased over the past decade and the evidence that low prices are the new normal for the foreseeable future.[30] Adjusting the LCOE calculation to reflect a future where gas prices don't rise radically increases the LCOE cost advantage of natural gas over wind/solar.

An LCOE incorporates an even more subjective feature, called the "discount rate," which is a way of comparing the value of money today versus the future. A low discount rate has the effect of tilting an outcome to make it more appealing to spend precious capital today to solve a future (theoretical) problem. Advocates of using low discount rates are essentially assuming slow economic growth.[31]

A high discount rate effectively assumes that a future society will be far richer than today (not to mention have better technology).[32] Economist William Nordhaus's work in this field, wherein he advocates using a high discount rate, earned him a 2018 Nobel Prize.

An LCOE also requires an assumption about average multi-decade capacity factors, the share of time the equipment actually operates (i.e., the real, not theoretical, amount of time the sun shines and wind blows). EIA assumes, for example, 41% and 29% capacity factors, respectively, for wind and solar. But data collected from operating wind and solar farms reveal actual median capacity factors of 33% and 22%.[33] The difference between assuming a 40% but experiencing a 30% capacity factor means that, over the 20-year life of a 2-MW wind turbine, $3 million of energy production assumed in the financial models won't exist—and that's for a turbine with an initial capital cost of about $3 million.

U.S. wind-farm capacity factors have been getting better but at a slow rate of about 0.7% per year over the past two decades.[34] Notably, this gain was achieved mainly by reducing the number of turbines per acre trying to scavenge moving air—resulting in average land used per unit of wind energy increasing by some 50%.

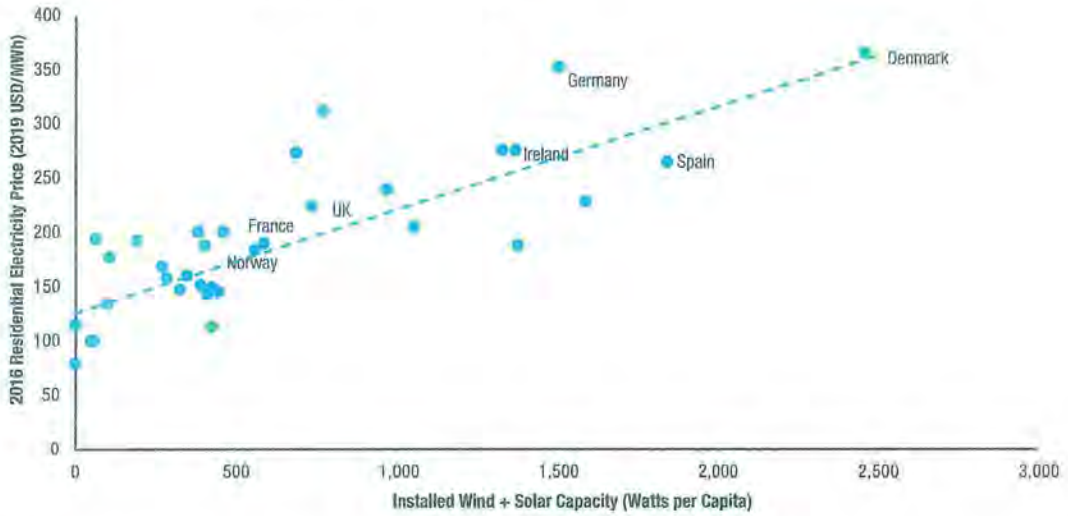
LCOE calculations do reasonably include costs for such things as taxes, the cost of borrowing, and maintenance. But here, too, mathematical outcomes give the appearance of precision while hiding assumptions. For example, assumptions about maintenance costs and performance of wind turbines over the long term may be overly optimistic. Data from the U.K., which is further down the wind-favored path than the U.S., point to far faster degradation (less electricity per turbine) than originally forecast.[35]

To address at least one issue with using LCOE as a tool, the International Energy Agency (IEA) recently proposed the idea of a "value-adjusted" LCOE, or VALCOE, to include the elements of flexibility and incorporate the economic implications of dispatchability. IEA calculations using a VALCOE method yielded coal power, for example, far cheaper than solar, with a cost penalty widening as a grid's share of solar generation rises.[36]

One would expect that, long before a grid is 100% wind/solar, the kinds of real costs outlined above should already be visible. As it happens, regardless of putative LCOEs, we do have evidence of the economic impact that arises from increasing the use of wind and solar energy.

FIGURE 3.

European Wind/Solar Capacity and Electricity Prices



Source: Eurostat, "Electricity Prices for Household Consumers—Bi-Annual Data (from 2007 Onwards)"

The Hidden Costs of a "Green" Grid

Subsidies, tax preferences, and mandates can hide real-world costs, but when enough of them accumulate, the effect should be visible in overall system costs. And it is. In Europe, the data show that the higher the share of wind/solar, the higher the average cost of grid electricity (**Figure 3**).

Germany and Britain, well down the "new energy" path, have seen average electricity rates rise 60%–110% over the past two decades.[37] The same pattern—more wind/solar and higher electricity bills—is visible in Australia and Canada.[38]

Since the share of wind power, on a per-capita basis, in the U.S. is still at only a small fraction of that in most of Europe, the cost impacts on American ratepayers are less dramatic and less visible. Nonetheless, average U.S. residential electric costs have risen some 20% over the past 15 years.[39] That should not have been the case. Average electric rates should have gone down, not up.

Here's why: coal and natural gas together supplied about 70% of electricity over that 15-year period.[40] The price of fuel accounts for about 60%–70% of the cost to produce electricity when using hydrocarbons.[41] Thus, about half the average cost of America's electricity depends on coal and gas prices. The price of both those fuels has gone down by over 50% over that 15-year period. Utility costs, specifically, to purchase gas and coal are down some 25% over the past decade alone. In other words, cost savings from the shale-gas revolution have significantly insulated consumers, so far, from even higher rate increases.

The increased use of wind/solar imposes a variety of hidden, physics-based costs that are rarely acknowledged in utility or government accounting. For example, when large quantities of power are rapidly, repeatedly, and unpredictably cycled up and down, the challenge and costs associated with "balancing" a grid (i.e., keeping it from failing) are greatly increased. OECD analysts estimate that at least some of those "invisible" costs imposed on the grid add 20%–50% to the cost of grid kilowatt-hours.[42]

Furthermore, flipping the role of the grid's existing power plants from primary to backup for wind/solar leads to other real but unallocated costs that emerge from physical realities. Increased cycling of conventional power plants increases wear-and-tear and maintenance costs. It also reduces the utilization of those expensive assets, which means that capital

costs are spread out over fewer kWh produced—thereby arithmetically increasing the cost of each of those kilowatt-hours.[43]

Then, if the share of episodic power becomes significant, the potential rises for complete system blackouts. That has happened twice after the wind died down unexpectedly (with some customers out for days in some areas) in the state of South Australia, which derives over 40% of its electricity from wind.[44]

After a total system outage in South Australia in 2018, Tesla, with much media fanfare, installed the world's single largest lithium battery "farm" on that grid.[45] For context, to keep South Australia lit for one half-day of no wind would require 80 such "world's biggest" Tesla battery farms, and that's on a grid that serves just 2.5 million people.

Engineers have other ways to achieve reliability; using old-fashioned giant diesel-engine generators as backup (engines essentially the same as those that propel cruise ships or that are used to back up data centers). Without fanfare, because of rising use of wind, U.S. utilities have been installing grid-scale engines at a furious pace. The grid now has over $4 billion in utility-scale, engine-driven generators (enough for about 100 cruise ships), with lots more to come. Most burn natural gas, though a lot of them are oil-fired. Three times as many such big reciprocating engines have been added to America's grid over the past two decades as over the half-century prior to that.[46]

All these costs are real and are not allocated to wind or solar generators. But electricity consumers pay them. A way to understand what's going on: managing grids with hidden costs imposed on non-favored players would be like levying fees on car drivers for the highway wear-and-tear caused by heavy trucks while simultaneously subsidizing the cost of fueling those trucks.

The issue with wind and solar power comes down to a simple point: their usefulness is impractical *on a national scale* as a major or primary fuel source for generating electricity. As with any technology, pushing the boundaries of practical utilization is possible but usually not sensible or cost-effective. Helicopters offer an instructive analogy.

The development of a practical helicopter in the 1950s (four decades after its invention) inspired widespread hyperbole about that technology revolutionizing personal transportation. Today, the manufacture and use of helicopters is a multibillion-dollar niche industry providing useful and often-vital services. But one would no more use helicopters for regular Atlantic travel—though doable with elaborate logistics—than employ a nuclear reactor to power a train or photovoltaic systems to power a country.

Batteries Cannot Save the Grid or the Planet

Batteries are a central feature of new energy economy aspirations. It would indeed revolutionize the world to find a technology that could store electricity as effectively and cheaply as, say, oil in a barrel, or natural gas in an underground cavern.[47] Such electricity-storage hardware would render it unnecessary even to build domestic power plants. One could imagine an OKEC (Organization of Kilowatt-Hour Exporting Countries) that shipped barrels of electrons around the world from nations where the cost to fill those "barrels" was lowest; solar arrays in the Sahara, coal mines in Mongolia (out of reach of Western regulators), or the great rivers of Brazil.

But in the universe that we live in, the cost to store energy in grid-scale batteries is, as earlier noted, about 200-fold more than the cost to store natural gas to generate electricity when it's needed.[48] That's why we store, at any given time, months' worth of national energy supply in the form of natural gas or oil.

Battery storage is quite another matter. Consider Tesla, the world's best-known battery maker: $200,000 worth of Tesla batteries, which collectively weigh over 20,000 pounds, are needed to store the energy equivalent of one barrel of oil.[49] A barrel of oil, meanwhile, weighs 300 pounds and can be stored in a $20 tank. Those are the *realities* of today's lithium batteries. Even a 200% improvement in underlying battery economics and technology won't close such a gap.

Nonetheless, policymakers in America and Europe enthusiastically embrace programs and subsidies to vastly expand the production and use of batteries at grid scale.[50] Astonishing quantities of batteries will be needed to keep country-level grids energized—and the level of mining required for the underlying raw materials would be epic. For the U.S., at least, given where the materials are mined and where batteries are made, imports would increase radically. Perspective on each of these realities follows.

How many batteries would it take to light the nation?

A grid based entirely on wind and solar necessitates going beyond preparation for the normal daily variability of wind and sun; it also means preparation for the frequency and duration of periods when there would be not only far less wind and sunlight combined but also for periods when there would be none of either. While uncommon, such a combined event—daytime continental cloud cover with no significant wind anywhere, or nighttime with no wind—has occurred more than a dozen times over the past century—effectively, once every decade. On these occasions, a combined wind/solar grid would not be able to produce a tiny fraction of the nation's electricity needs. There have also been frequent one-hour periods when 90% of the national electric supply would have disappeared.[51]

So how many batteries would be needed to store, say, not two months' but two days' worth of the nation's electricity? The $5 billion Tesla "Gigafactory" in Nevada is currently the world's biggest battery manufacturing facility.[52] Its total annual production could store three *minutes'* worth of annual U.S. electricity demand. Thus, in order to fabricate a quantity of batteries to store two days' worth of U.S. electricity demand would require 1,000 years of Gigafactory production.

Wind/solar advocates propose to minimize battery usage with enormously long transmission lines on the observation that it is always windy or sunny somewhere. While theoretically feasible (though not always true, even at country-level geographies), the length of transmission needed to reach somewhere "always" sunny/windy also entails substantial reliability and security challenges. (And long-distance transport of energy by wire is twice as expensive as by pipeline.)[53]

Building massive quantities of batteries would have epic implications for mining

A key rationale for the pursuit of a new energy economy is to reduce environmental externalities from the use of hydrocarbons. While the focus these days is mainly on the putative long-term effects of carbon dioxide, all forms of energy production entail various unregulated externalities inherent in extracting, moving, and processing minerals and materials.

Radically increasing battery production will dramatically affect mining, as well as the energy used to access, process, and move minerals and the energy needed for the battery fabrication process itself. About 60 pounds of batteries are needed to store the energy equivalent to that in one pound of hydrocarbons. Meanwhile, 50–100 pounds of various materials are mined, moved, and processed for one pound of battery produced.[54] Such underlying realities translate into enormous quantities of minerals—such as lithium, copper, nickel, graphite, rare earths, and cobalt—that would need to be extracted from the earth to fabricate batteries for grids and cars.[55] A battery-centric future means a world mining gigatons more materials.[56] And this says nothing about the gigatons of materials needed to fabricate wind turbines and solar arrays, too.[57]

Even without a new energy economy, the mining required to make batteries will soon dominate the production of many minerals. Lithium battery production today already accounts for about 40% and 25%, respectively, of all lithium and cobalt mining.[58] In an all-battery future, global mining would have to expand by more than 200% for copper, by at least 500% for minerals like lithium, graphite, and rare earths, and far more than that for cobalt.[59]

Then there are the hydrocarbons and electricity needed to undertake all the mining activities and to fabricate the batteries themselves. In rough terms, it requires the energy equivalent of about 100 barrels of oil to fabricate a quantity of batteries that can store a single barrel of oil-equivalent energy.[60]

Given the regulatory hostility to mining on the U.S. continent, a battery-centric energy future virtually guarantees more mining elsewhere and rising import dependencies for America. Most of the relevant mines in the world are in Chile, Argentina, Australia, Russia, the Congo, and China. Notably, the Democratic Republic of Congo produces 70% of global cobalt, and China refines 40% of that output for the world.[61]

China already dominates global battery manufacturing and is on track to supply nearly two-thirds of all production by 2020.[62] The relevance for the new energy economy vision: 70% of China's grid is fueled by coal today and will still be at 50% in 2040.[63] This means that, over the life span of the batteries, there would be *more* carbon-dioxide emissions associated with manufacturing them than would be offset by using those batteries to, say, replace internal combustion engines.[64]

Transforming personal transportation from hydrocarbon-burning to battery-propelled vehicles is another

central pillar of the new energy economy. Electric vehicles (EVs) are expected not only to replace petroleum on the roads but to serve as backup storage for the electric grid as well.[65]

Lithium batteries have finally enabled EVs to become reasonably practical. Tesla, which now sells more cars in the top price category in America than does Mercedes-Benz, has inspired a rush of the world's manufacturers to produce appealing battery-powered vehicles.[66] This has emboldened bureaucratic aspirations for outright bans on the sale of internal combustion engines, notably in Germany, France, Britain, and, unsurprisingly, California.

Such a ban is not easy to imagine. Optimists forecast that the number of EVs in the world will rise from today's nearly 4 million to 400 million in two decades.[67] A world with 400 million EVs by 2040 would decrease global oil demand by barely 6%. This sounds counterintuitive, but the numbers are straightforward. There are about 1 billion automobiles today, and they use about 30% of the world's oil.[68] (Heavy trucks, aviation, petrochemicals, heat, etc. use the rest.) By 2040, there would be an estimated 2 billion cars in the world. Four hundred million EVs would amount to 20% of all the cars on the road—which would thus replace about 6% of petroleum demand.

In any event, batteries don't represent a revolution in personal mobility equivalent to, say, going from the horse-and-buggy to the car—an analogy that has been invoked.[69] Driving an EV is more analogous to changing what horses are fed and importing the new fodder.

Moore's Law Misapplied

Faced with all the realities outlined above regarding green technologies, new energy economy enthusiasts nevertheless believe that true breakthroughs are yet to come and are even inevitable. That's because, so it is claimed, energy tech will follow the same trajectory as that seen in recent decades with computing and communications. The world will yet see the equivalent of an Amazon or "Apple of clean energy."[70]

This idea is seductive because of the astounding advances in silicon technologies that so few forecasters anticipated decades ago. It is an idea that renders moot any cautions that wind/solar/batteries are too expensive today—such caution is seen as foolish and shortsighted, analogous to asserting, circa 1980, that the average citizen would never be able to afford a computer. Or saying, in 1984 (the year that the world's first cell phone was released), that a billion people would own a cell phone, when it cost $9,000 (in today's dollars). It was a two-pound "brick" with a 30-minute talk time.

Today's smartphones are not only far cheaper; they are far more powerful than a room-size IBM mainframe from 30 years ago. That transformation arose from engineers inexorably shrinking the size and energy appetite of transistors, and consequently increasing their number per chip roughly twofold every two years—the "Moore's Law" trend, named for Intel cofounder Gordon Moore.

The compound effect of that kind of progress has indeed caused a revolution. Over the past 60 years, Moore's Law has seen the efficiency of how logic engines *use* energy improve by over a billionfold.[71] But a similar transformation in how energy is *produced* or *stored* isn't just unlikely; it can't happen with the physics we know today.

In the world of people, cars, planes, and large-scale industrial systems, increasing speed or carrying capacity causes hardware to expand, not shrink. The energy needed to move a ton of people, heat a ton of steel or silicon, or grow a ton of food is determined by properties of nature whose boundaries are set by laws of gravity, inertia, friction, mass, and thermodynamics.

If combustion engines, for example, could achieve the kind of scaling efficiency that computers have since 1971—the year the first widely used integrated circuit was introduced by Intel—a car engine would generate a thousandfold *more* horsepower and shrink to the size of an *ant*.[72] With such an engine, a car could actually fly, very fast.

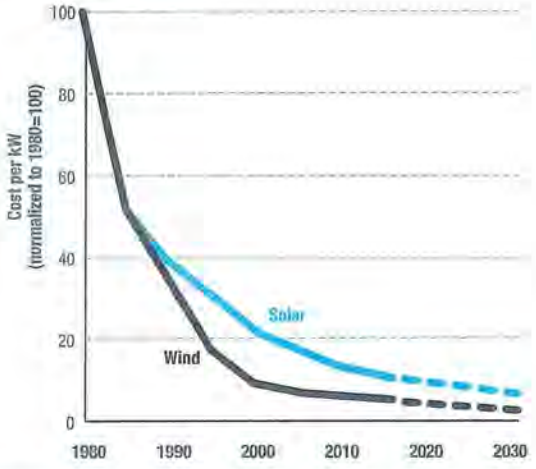
If photovoltaics scaled by Moore's Law, a single post-age-stamp-size solar array would power the Empire State Building. If batteries scaled by Moore's Law, a battery the size of a book, costing three cents, could power an A380 to Asia.

But only in the world of comic books does the physics of propulsion or energy production work like that. In our universe, power scales the other way.

An ant-size engine—which has been built—produces roughly 100,000 times *less* power than a Prius. An ant-size solar PV array (also feasible) produces a thousand-fold less energy than an ant's biological muscles. The energy equivalent of the aviation fuel actually used by an aircraft flying to Asia would take $60 million worth of Tesla-type batteries weighing five times more than that aircraft.[73]

FIGURE 4.

Cost Reductions for Wind and Solar Power, 1980–2030



Source: Data drawn from Massachusetts Institute of Technology, Energy Initiative, "The Future of Solar Energy: An Interdisciplinary MIT Study," 2015; Johannes N. Mayer, "Current and Future Cost of Photovoltaics," Agora Energiewende, February 2015; David Feldman et al., "NREL Photovoltaic Pricing Trends: Historical, Recent, and Near-Term Projections," National Renewable Energy Laboratory (NREL), Aug. 25, 2015; Ryan Wiser et al., "Forecasting Wind Energy Costs and Cost Drivers," Lawrence Berkeley National Laboratory, June 2016; Ran Fu, David Feldman, and Robert Margolis, "U.S. Solar Photovoltaic System Cost Benchmark: Q1 2018," NREL, November 2018

The challenge in storing and processing information using the smallest possible amount of energy is distinct from the challenge of producing energy, or of moving or reshaping physical objects. The two domains entail different laws of physics.

The world of logic is rooted in simply knowing and storing the fact of the binary state of a switch—i.e., whether it is on or off. Logic engines don't produce physical action but are designed to manipulate the *idea* of the numbers zero and one. Unlike engines that carry people, logic engines can use software to do things such as compress information through clever mathematics and thus reduce energy use. No comparable compression options exist in the world of humans and hardware.

Of course, wind turbines, solar cells, and batteries will continue to improve significantly in cost and performance; so will drilling rigs and combustion turbines (a subject taken up next). And, of course, Silicon Valley information technology will bring important, even dramatic, efficiency gains in the production and management of energy and physical goods (a prospect also taken up below). But the outcomes won't be as miraculous as the invention of the integrated circuit, or the discovery of petroleum or nuclear fission.

Sliding Down the Renewable Asymptote

Forecasts for a continual rapid decline in costs for wind/solar/batteries are inspired by the gains that those technologies have already experienced. The first two decades of commercialization, after the 1980s, saw a 10-fold reduction in costs. But the path for improvements now follows what mathematicians call an asymptote; or, put in economic terms, improvements are subject to a law of diminishing returns where every incremental gain yields less progress than in the past (**Figure 4**).

This is a normal phenomenon in all physical systems. Throughout history, engineers have achieved big gains in the early years of a technology's development, whether wind or gas turbines, steam or sailing ships, internal combustion or photovoltaic cells. Over time, engineers manage to approach nature's limits. Bragging rights for gains in efficiency—or speed, or other equivalent metrics such as energy density (power per unit of weight or volume) then shrink from double-digit percentages to fractional percentage changes. Whether it's solar, wind tech, or aircraft turbines, the gains in performance are now all measured in single-digit percentage gains. Such progress is economically meaningful but is not revolutionary.

The physics-constrained limits of energy systems are unequivocal. Solar arrays *can't* convert more photons than those that arrive from the sun. Wind turbines *can't* extract more energy than exists in the kinetic flows of moving air. Batteries *are* bound by the physical chemistry of the molecules chosen. Similarly, no matter how much better jet engines become, an A380 will *never* fly to the moon. An oil-burning engine *can't* produce more energy than what is contained in the physical chemistry of hydrocarbons.

Combustion engines have what's called a Carnot Efficiency Limit, which is anchored in the temperature of combustion and the energy available in the fuel. The limits are long established and well understood. In theory, at a high enough temperature, 80% of the chemical energy that exists in the fuel can be turned into power.[74] Using today's high-temperature materials, the best hydrocarbon engines convert about 50%–60% to power. There's still room to improve but nothing like the 10-fold to nearly hundredfold revolu-

tionary advances achieved in the first couple of decades after their invention. Wind/solar technologies are now on the same place of that asymptotic technology curve.

For wind, the boundary is called the Betz Limit, which dictates how much of the kinetic energy in air a blade can capture; that limit is about 60%.[75] Capturing all the kinetic energy would mean, by definition, no air movement and thus nothing to capture. There needs to be wind for the turbine to turn. Modern turbines already exceed 45% conversion.[76] That leaves some real gains to be made but, as with combustion engines, nothing revolutionary.[77] Another 10-fold improvement is not possible.

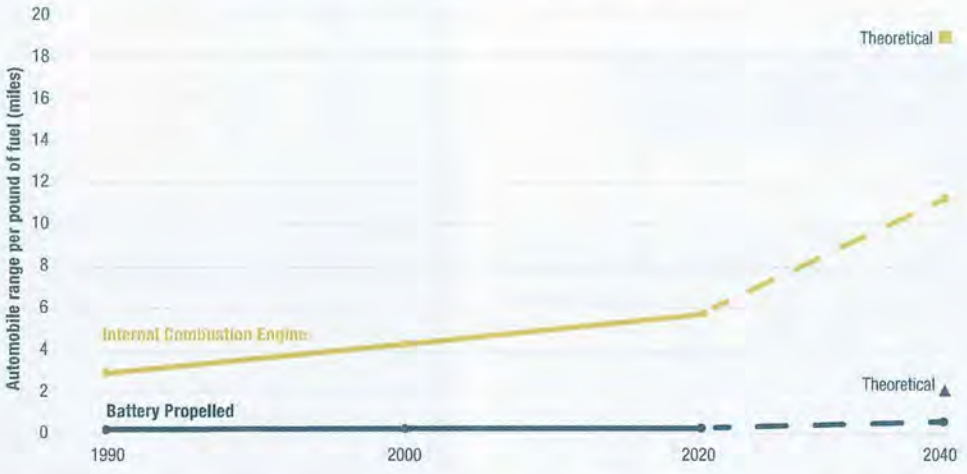
For silicon photovoltaic (PV) cells, the physics boundary is called the Shockley-Queisser Limit: a maximum of about 33% of incoming photons are converted into electrons. State-of-the-art commercial PVs achieve just over 26% conversion efficiency—in other words, near the boundary. While researchers keep unearthing new non-silicon options that offer tantalizing performance improvements, all have similar physics boundaries, and none is remotely close to manufacturability at all—never mind at low costs.[78] There are no 10-fold gains left.[79]

Future advances in wind turbine and solar economics are now centered on incremental engineering improvements: economies of scale in making turbines enormous, taller than the Washington Monument, and similarly massive, square-mile utility-scale solar arrays. For both technologies, all the underlying key components—concrete, steel, and fiberglass for wind; and silicon, copper, and glass for solar—are all already in mass production and well down asymptotic cost curves in their own domains.

While there are no surprising gains in economies of scale available in the supply chain, that doesn't mean that costs are immune to improvements. In fact, all manufacturing processes experience continual improvements in production efficiency as volumes rise. This experience curve is called Wright's Law. (That "law" was first documented in 1936, as it related then to the challenge of manufacturing aircraft at costs that markets could tolerate. Analogously, while aviation took off and created a big, worldwide transportation industry, it didn't eliminate automobiles, or the need for ships.) Experience leading to lower incremental costs is to be expected; but, again, that's not the kind of revolutionary improvement that could make a new energy economy even remotely plausible.

FIGURE 5.

Tale of the Tape: Battery vs. Hydrocarbon Energy Density for Propulsion



Source: Author calculations: Michael M. Thackeray, Christopher Wolverton, and Eric D. Isaacs, "Electrical Energy Storage for Transportation—Approaching the Limits of, and Going Beyond, Lithium-Ion Batteries," *Energy & Environmental Science* 7, no. 5 (May 2012): 7854-63; Richard Van Noorden, "The Rechargeable Revolution: A Better Battery," *Nature* 507, no. 7490, (March 2014): 26–8; Anton Wahlman, "The New 39 MPG Toyota SUV vs. Tesla Model 3: Same Fuel Cost per Mile," Seeking Alpha, Nov. 20, 2018; Kevin Bullis, "70 mpg, Without a Hybrid," MIT Technology Review, Oct. 25, 2010; Justin Hughes, "Toyota Develops World's Most Thermally Efficient 2.0-Liter Engine," The Drive, Mar. 1, 2018

As for modern batteries, there are still promising options for significant improvements in their underlying physical chemistry. New non-lithium materials in research labs offer as much as a 200% and even 300% gain in inherent performance.[80] Such gains nevertheless don't constitute the kinds of 10-fold or hundredfold advances in the early days of combustion chemistry.[81] Prospective improvements will still leave batteries miles away from the real competition: petroleum.

There are no subsidies and no engineering from Silicon Valley or elsewhere that can close the physics-centric gap in energy densities between batteries and oil (**Figure 5**). The energy stored per pound is the critical metric for vehicles and, especially, aircraft. The maximum potential energy contained in oil molecules is about 1,500% greater, pound for pound, than the maximum in lithium chemistry.[82] That's why the aircraft and rockets are powered by hydrocarbons. And that's why a 20% improvement in oil propulsion (eminently feasible) is more valuable than a 200% improvement in batteries (still difficult).

Finally, when it comes to limits, it is relevant to note that the technologies that unlocked shale oil and gas are still in the early days of engineering development, unlike the older technologies of wind, solar, and batteries. Tenfold gains are still possible in terms of how much energy can be extracted by a rig from shale rock before approaching physics limits.[83] That fact helps explain why shale oil and gas have added 2,000% more to U.S. energy production over the past decade than have wind and solar combined.[84]

Digitalization Won't Uberize the Energy Sector

Digital tools are already improving and can further improve all manner of efficiencies across entire swaths of the economy, and it is reasonable to expect that software will yet bring significant improvements in both the underlying efficiency of wind/solar/battery machines and in the efficiency of how such machines are integrated into infrastructures. Silicon logic has improved, for example, the control and thus the fuel efficiency of combustion engines, and it is doing the same for wind turbines. Similarly, software epitomized by Uber has shown that optimizing the efficiency of *using* expensive transportation assets lowers costs. Uberizing all manner of capital assets is inevitable.

Uberizing the electric grid without hydrocarbons is another matter entirely.

The peak demand problem that software can't fix

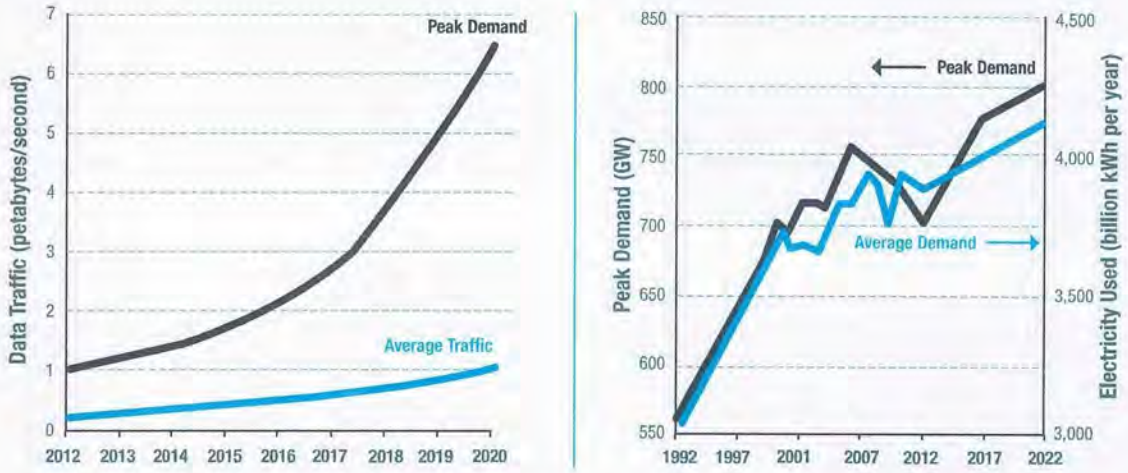
In the energy world, one of the most vexing problems is in optimally matching electricity supply and demand (**Figure 6**). Here the data show that society and the electricity-consuming services that people like are generating a growing gap between peaks and valleys of demand. The net effect for a hydrocarbon-free grid will be to increase the need for batteries to meet those peaks.

All this has relevance for encouraging EVs. In terms of managing the inconvenient cyclical nature of demand, shifting transportation fuel use from oil to the grid will make peak management far more challenging. People tend to refuel when it's convenient; that's easy to accommodate with oil, given the ease of storage. EV refueling will exacerbate the already-episodic nature of grid demand.

To ameliorate this problem, one proposal is to encourage or even require off-peak EV fueling.[85] The jury is out on just how popular that will be or whether it will even be tolerated.

FIGURE 6.

Peak vs. Average Demand: Data Traffic & Electricity



Source: Cisco, "Visual Networking Index: Forecast and Trends, 2017–2022 White Paper," Feb. 27, 2019; EIA, "Annual Energy Outlook 2019," EIA; "Electricity Data: Noncoincident Peak Load," 2016; EIA, "Peak-to-Average Electricity Demand Ratio Rising in New England and Many Other U.S. Regions," Feb. 18, 2014; EPRI (Electric Power Research Institute), "The Integrated Grid: Capacity and Energy in the Integrated World," 2015

Although kilowatt-hours and cars—key targets in the new energy economy prescriptions—constitute only 60% of the energy economy, global demand for both is centuries away from saturation. Green enthusiasts make extravagant claims about the effect of Uber-like options and self-driving cars. However, the data show that the economic efficiencies from Uberizing have so far increased the use of cars and peak urban congestion.[86] Similarly, many analysts now see autonomous vehicles amplifying, not dampening, that effect.[87]

That's because people, and thus markets, are focused on economic efficiency and not on energy efficiency. The former can be associated with reducing energy use; but it is also, and more often, associated with increased energy demand. Cars use more energy per mile than a horse, but the former offers enormous gains in economic efficiency. Computers, similarly, use far more energy than pencil-and-paper.

Uberizing improves energy efficiencies but increases demand

Every energy conversion in our universe entails built-in inefficiencies—converting heat to propulsion, carbohydrates to motion, photons to electrons, electrons to data, and so forth. All entail a certain energy cost, or waste, that can be reduced but never eliminated. But, in no small irony, history shows—as economists have often noted—that improvements in efficiency lead to increased, not decreased, energy consumption.

If at the dawn of the modern era, affordable steam engines had remained as inefficient as those first invented, they would never have proliferated, nor would the attendant economic gains and the associated rise in coal demand have happened. We see the same thing with modern combustion engines. Today's aircraft, for example, are three times as energy-efficient as the first commercial passenger jets in the 1950s.[88] That didn't reduce fuel use but propelled air traffic to soar and, with it, a fourfold rise in jet fuel burned.[89]

Similarly, it was the astounding gains in computing's energy efficiency that drove the meteoric rise in data traffic on the Internet—which resulted in far more energy used by computing. Global computing and communications, all told, now consumes the energy equivalent of 3 billion barrels of oil per year, *more* energy than global aviation.[90]

The purpose of improving efficiency in the real world, as opposed to the policy world, is to reduce the cost of enjoying the benefits from an energy-consuming engine

or machine. So long as people and businesses want more of the benefits, declining cost leads to increased demand that, on average, outstrips any "savings" from the efficiency gains. **Figure 7** shows how this efficiency effect has played out for computing and air travel.[91]

Of course, the growth in demand growth for a specific product or service can subside in a (wealthy) society when limits are hit: the amount of food a person can eat, the miles per day an individual is willing to drive, the number of refrigerators or lightbulbs per household, etc. But a world of 8 billion people is a long way from reaching any such limits.

The macro picture of the relationship between efficiency and world energy demand is clear (**Figure 8**). Technology has continually improved society's energy efficiency. But far from ending global energy growth, efficiency has enabled it. The improvements in cost and efficiency brought about through digital technologies will accelerate, not end, that trend.

Energy Revolutions Are Still Beyond the Horizon

When the world's poorest 4 billion people increase their energy use to just 15% of the per-capita level of developed economies, global energy consumption will rise by the equivalent of adding an entire United States' worth of demand.[92] In the face of such projections, there are proposals that governments should constrain demand, and even ban certain energy-consuming behaviors. One academic article proposed that the "sale of energy-hungry versions of a device or an application could be forbidden on the market, and the limitations could become gradually stricter from year to year, to stimulate energy-saving product lines."[93] Others have offered proposals to "reduce dependency on energy" by restricting the sizes of infrastructures or requiring the use of mass transit or car pools.[94]

The issue here is not only that poorer people will inevitably want to—and will be able to—live more like wealthier people but that new inventions continually create new demands for energy. The invention of the aircraft means that every $1 billion in new jets produced leads to some $5 billion in aviation fuel consumed over two decades to operate them. Similarly, every $1 billion in data centers built will consume $7 billion in electricity over the same period.[95] The world is buying both at the rate of about $100 billion a year.[96]

The inexorable march of technology progress for things that *use* energy creates the seductive idea that something radically new is also inevitable in ways to *produce* energy. But sometimes, the old or established technology is the optimal solution and nearly immune to disruption. We still use stone, bricks, and concrete, all of which date to antiquity. We do so because they're optimal, not "old." So are the wheel, water pipes, electric wires ... the list is long. Hydrocarbons are, so far, optimal ways to power most of what society needs and wants.

More than a decade ago, Google focused its vaunted engineering talent on a project called "RE<C," seeking to develop renewable energy cheaper than coal. After the project was canceled in 2014, Google's lead engineers wrote: "Incremental improvements to existing [energy] technologies aren't enough; we need something truly disruptive. ... We don't have the answers."[97] Those engineers rediscovered the kinds of physics and scale realities highlighted in this paper.

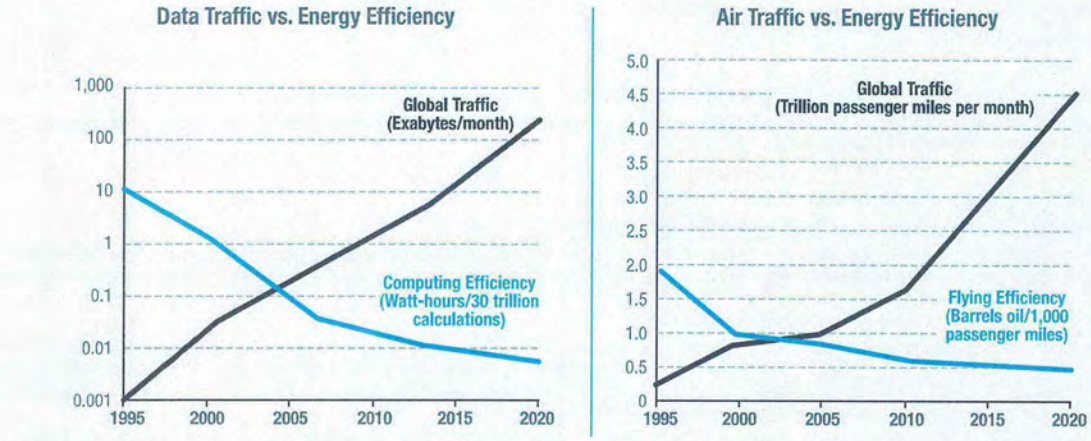
An energy revolution will come only from the pursuit of basic sciences. Or, as Bill Gates has phrased it, the challenge calls for scientific "miracles."[98] These will emerge from basic research, not from subsidies for yesterday's technologies. The Internet didn't emerge from subsidizing the dial-up phone, or the transistor from subsidizing vacuum tubes, or the automobile from subsidizing railroads.

However, 95% of private-sector R&D spending and the majority of government R&D is directed at "development" and not basic research.[99] If policymakers want a revolution in energy tech, the single most important action would be to radically refocus and expand support for *basic* scientific research.

Hydrocarbons—oil, natural gas, and coal—are the world's principal energy resource today and will continue to be so in the foreseeable future. Wind turbines, solar arrays, and batteries, meanwhile, constitute a small source of energy, and physics dictates that they will remain so. Meanwhile, there is simply no possibility that the world is undergoing—or can undergo—a near-term transition to a "new energy economy."

FIGURE 7.

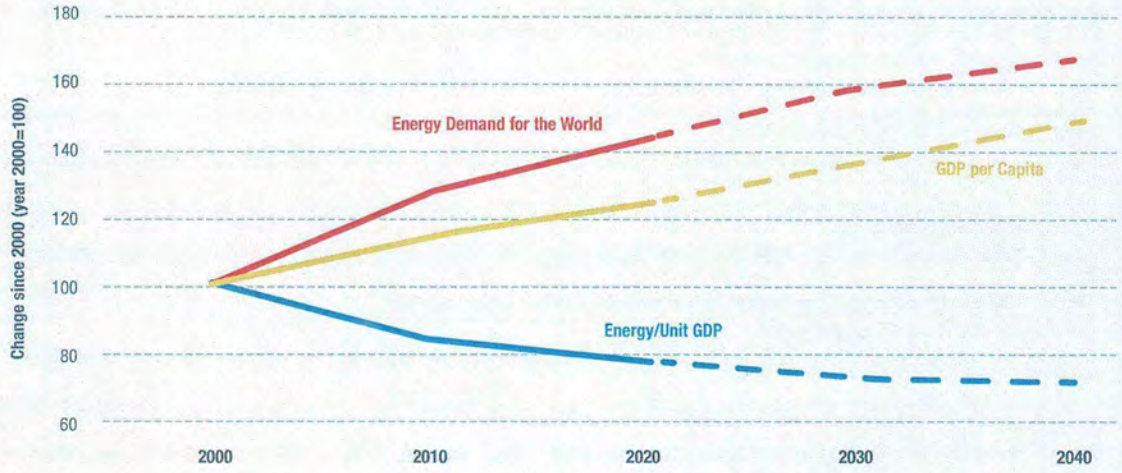
Increasing Energy Efficiency Increases Demand



Sources: Cisco, "Visual Networking Index: Forecast and Trends, 2017–2022 White Paper," Feb. 27, 2019; Jonathan Koomey et al., "Implications of Historical Trends in the Electrical Efficiency of Computing," *IEEE Annals of the History of Computing* 33, no. 3 (March 2011): 46–54; Timothy Prickett Morgan, "Alchemy Can't Save Moore's Law," The Next Platform, June 24, 2016; Joosung Lee and Jeonhgoon Mo, "Analysis of Technological Innovation and Environmental Performance Improvement in Aviation Sector," *International Journal of Environmental Research and Public Health* 8, no. 9 (July–September 2011): 3777–95; IATA (International Air Transport Association), "Air Passenger Market Analysis," December 2018

FIGURE 8.

As Global Efficiency Improves, Energy Demand Rises



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13 Capital costs and capacity factors from Lazard, "Lazard's Levelized Cost of Energy Analysis," 2018: Our calculations here a) overstate wind and solar output since both degrade in operational efficiency over time, and b) optimistically assume equal cost for the technologies needed to convert wind/solar and natural gas into grid-useful power, whereas battery $/kW is actually >2x the cost of a natural-gas generator.

14 This calculation includes a production decline curve. Capital cost and total recovery/production data are from Gulfport Energy, Credit Suisse Energy Summit, 2019; and Cabot Oil & Gas, Heikkinen Energy Conference, 2018.

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