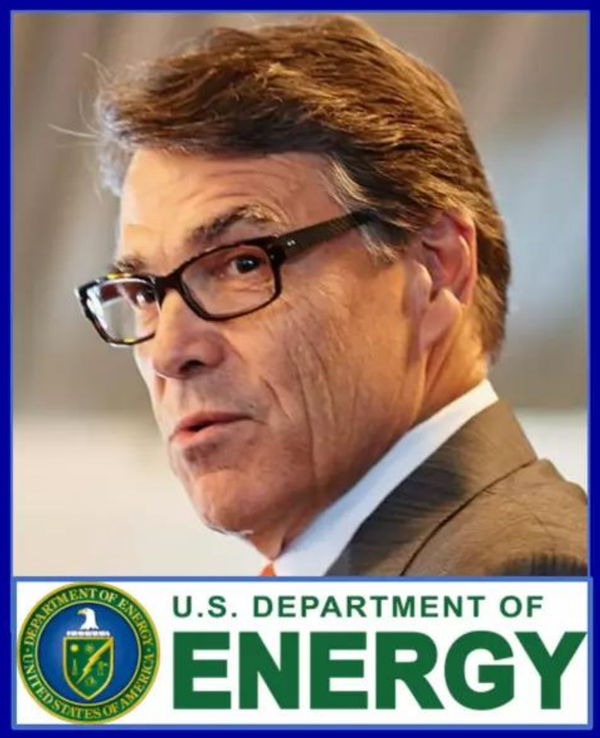
Lattice Energy LLC

U.S. Secretary of Energy Rick Perry heavily criticized for controversial DOE letter to FERC re coal and nuclear power

Suggested coal and nuclear should be compensated somehow for special value to grid resiliency provided by uninterruptible power

Further suggested requirement for receiving such compensation would be that eligible dispatchable generation assets must be able to store enough fuel onsite to permit 90 days of uninterrupted electric power generation

Maybe DOE suggestions are reasonable when you get past energy politics?



Lewis G. Larsen
President and CEO
Lattice Energy LLC
October 23, 2017

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Future impact of climate change on grids is *terra incognita*

Complex problem: insure future reliability and resiliency of electric power

Cost-effective use of electric grid's existing power generation assets

Ongoing climate change creates extreme weather events

Rise of renewables: disruptive shift in power generation technology

Urgent need to reduce societal CO_2 emissions

Common criticisms of Secretary Perry's FERC directive

Many players in environmental lobbying community howling in protest

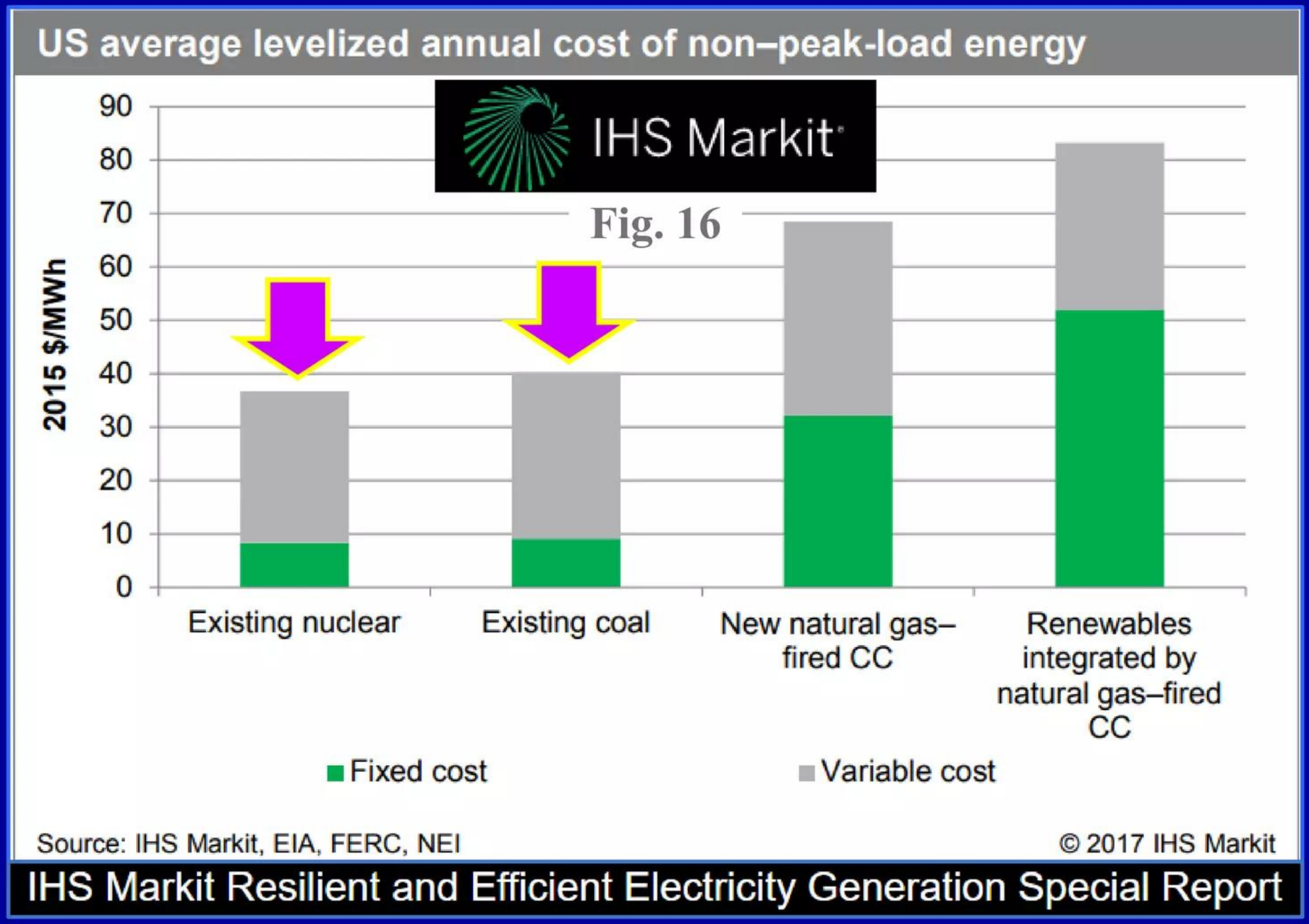
Bottom line: many special interests don't want any changes to today's status quo

- Special compensation for nuclear and coal generation amounts to "subsidy" or "bailout" for "uneconomic" types of power generation
- Existing nuclear and coal power plants would be undeservedly "saved" from closing because of the "cruel vicissitudes of market competition"
- Cost-recovery adjustments would be a heavy government "thumb on the scale" that will likely "kill electricity competition" between traditional dispatchable and newer, non-dispatchable renewable power sources
- Rule changes would "fundamentally distort and destroy power markets"
- Changes would be "striking reversal of twenty years of regulatory restructuring" --- a.k.a. deregulation of U.S. electric utility industry
- Financial incentives for nuclear and coal operators to compensate for special contribution to grid resilience amounts to a "tax on consumers"
- Implementation of changes to rules would reverse progress in greatly reducing CO_2 emissions coming from electric power generation in USA

Dispatchable, uninterruptible nuclear & coal are competitive

Renewables integrated w. natural gas are higher $ vs. nuclear or coal

Existing nuclear & coal plants very cost-effective for grid power generation



https://www.ihs.com/Info/0917/electricity-generation-special-report.html

Source documents & testimony reveal what Perry really said

Relevant documents and Perry's testimony to Congress about directive

Many of Perry's valid points are being distorted by parties with axes to grind

Copy of DOE directive letter that Perry originally sent to U.S. FERC Chairman and two Commissioners on Sept. 28, 2017 (pdf file):

https://energy.gov/sites/prod/files/2017/09/f37/Secretary%20Rick%20Perry%27s%20Letter%20to%20the%20Federal%20Energy%20Regulatory%20Commission.pdf

FERC response on Oct. 4, 2017 to Perry's Sept. 28 DOE letter (pdf file):

https://www.ferc.gov/media/headlines/2017/2017-3/10-04-17.pdf

Energy Industry Associations' joint response to Perry's DOE directive to FERC (pdf file):

http://americanbiogascouncil.org/pdf/Joint%20Energy%20Assoc%20Motion%20Extension.filed.copy.pdf

Prepared remarks Secretary Perry provided to U.S. House Committee on Energy and Commerce's Subcommittee on Energy prior to testimony on Oct. 12, 2017 (pdf file):

http://docs.house.gov/meetings/IF/IF03/20171012/106506/HHRG-115-IF03-Wstate-PerryR-20171012.pdf

Videotape of Perry's Oct. 12, 2017 live testimony before House Energy and Commerce's Subcommittee on Energy about controversial DOE directive letter to FERC and other issues (length 1 hour 48 minutes):

https://www.youtube.com/watch?v=M_eopvfK8Lc

Quotes and paraphrasing of Perry's comments re FERC letter

Goal with letter was to "kickstart" discussion of grid reliability/resiliency

DOE: we need to anticipate future threats to grid resilience *before* they happen

- Perry said insuring national energy security, grid reliability/resiliency, and fostering innovation in energy are key elements of DOE's mission
- Didn't characterize FERC letter as "directive"; rather DOE goal was to "kickstart" important "discussion about grid reliability and resiliency"
- Perry said DOE suggestions were an attempt to "think outside the box," learn from "every [new] disaster" involving climate change, and "look forward into the future" to see whether there were changes that might be made to present electric power generation infrastructure that could help insure even better grid reliability/resiliency further into the future given that renewables account for an increasing % of generation assets
- Committee member Bobby Rush said historical data showed that grid reliability was recently much-improved even though renewables were larger % of generation mix; Perry answered: past reliability statistics don't necessarily predict what might happen in the future and that the "wind doesn't always blow, the sun doesn't always shine, and natural gas pipelines don't always have enough capacity to meet demand"

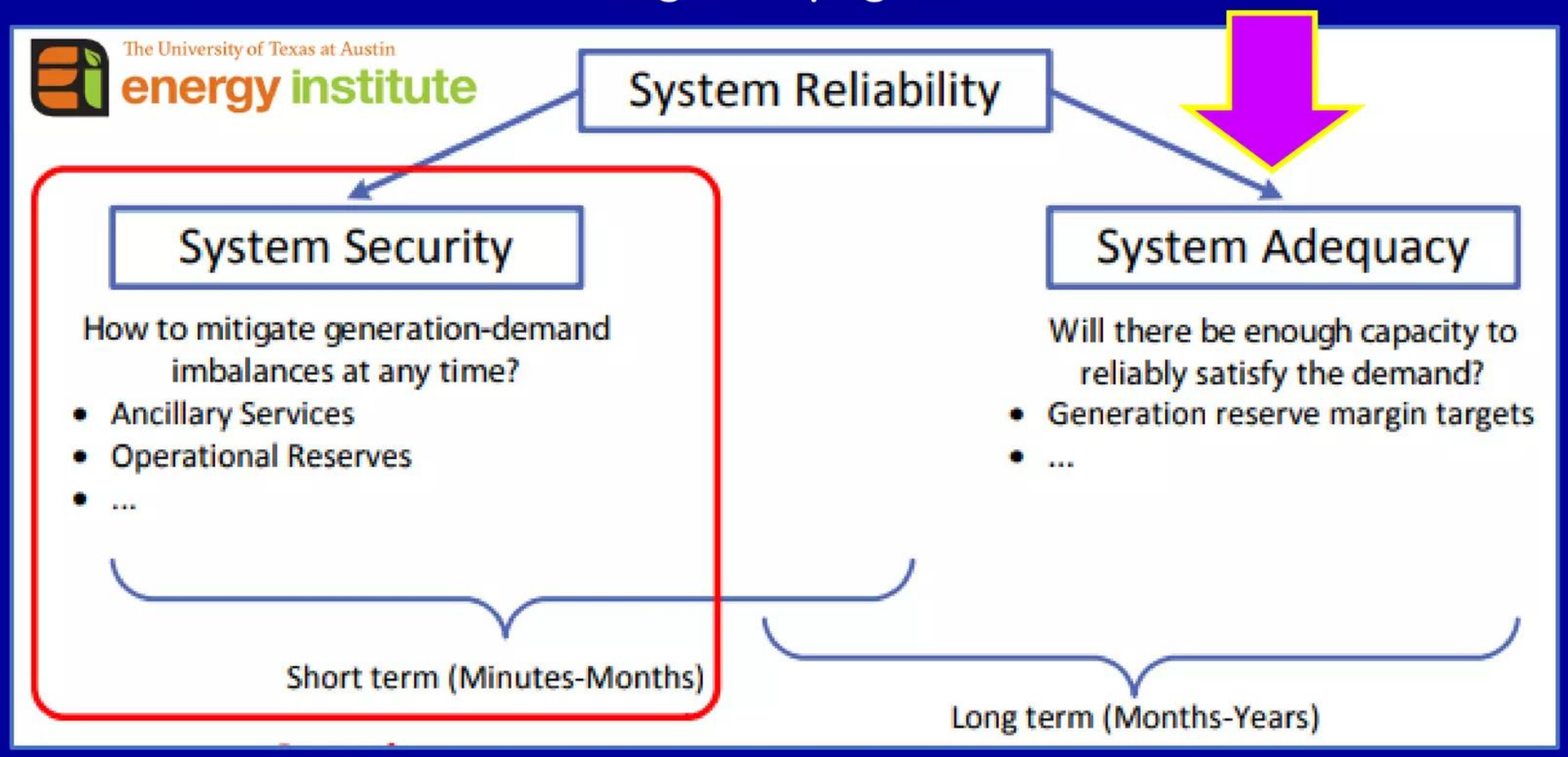
This is what Perry & DOE mean re looking forward into future

System adequacy: will grid power be resilient to effects of future weather

Grid generation mix must be able handle extreme weather from climate change

"Impact of renewable generation on operational reserves requirements: when more could be less" - Energy Institute at University of Texas (Austin)

Fig. 1 on page 4



https://live-energy-institute.pantheonsite.io/sites/default/files/UTAustin_FCe_Ancillary_2017.pdf

This is what Perry & DOE mean re looking forward into future

System adequacy: will grid power be resilient to effects of future weather

Mixture of generation types in installed capacity has impact on grid's adequacy

The University of Texas at Austin energy institute

Quote from page 4

The Full Cost of Electricity (FCe-)

"On the other hand, in the long term the concern is whether there is enough installed capacity to satisfy an increasing peak demand, that is, the concern is with so-called resource adequacy. A traditional metric used in this context is the reserve margin, which is the quotient between peak power demand (forecast, in case of forward estimates) divided by the installed power (again, including forecast new resources in case of forward estimates). Based on the descriptions presented above, the traditional time separation to analyze generation reliability is as presented in Figure 1, which is based on [1]. In the picture it is illustrated that this report is only focused in a part of the system security problem. It is important to keep in mind that some terminology used in the security context might appear in the context of resource adequacy, but with a somewhat or completely different meaning. For example, reserves in the context of operational reserves is something different to reserves for reserve margin."

https://live-energy-institute.pantheonsite.io/sites/default/files/UTAustin_FCe_Ancillary_2017.pdf

This is what Perry & DOE mean re looking forward into future

System adequacy: will grid power be resilient to effects of future weather

High % of non-dispatchable renewable generation capacity affects grid reliability

"Impact of renewable generation on operational reserves requirements: when more could be less" - Energy Institute at University of Texas (Austin)

The University of Texas at Austin energy institute

Quote from page 5

The Full Cost of Electricity (FCe-)

"Nowadays there are concerns about the capability to maintain reliability under different disruptive technology changes. One of those changes is the massive development of utility scale renewable generation, whose fluctuating nature is of concern for maintaining security and generation adequacy for power systems. It is important to note that 'system security' or 'security' in the context of this report are related to maintaining reliable delivery of power to the loads and avoiding disruptions of electricity service to customers."

https://live-energy-institute.pantheonsite.io/sites/default/files/UTAustin_FCe_Ancillary_2017.pdf

Quotes and paraphrasing of Perry's comments re FERC letter

Acknowledges climate change; feels nuclear has role to play in resiliency

"Broad, all-of-the-above energy strategy that is as free market as it can be"

- Perry acknowledged that disruptive "climate change is happening" but doesn't believe it is certain that such change is "100% human-caused"
- When committee member asked Perry, "Do we have a national security interest in nuclear power?" He answered, "Yes." In other words, Perry believes nuclear power has role to play in insuring future grid resiliency
- Perry said he was very strong supporter of expanding wind power and deregulation of electricity markets while serving as Governor of Texas; definitive assertion was affirmed by a committee member from Texas
- Perry advocates "broad, all-of-the-above energy strategy that is as free market as it can be." DOE strategy posits masterminding some sort of a balanced, diversified mixture of dispatchable (nuclear, coal, natural gas) and non-dispatchable (wind, solar, hydro) grid-connected electric power generation assets that can effectively maximize future grid reliability and resiliency, i.e. 99^{+} % uptime at minimum-possible cost to consumers. He believes cost-effective balance can be achieved with combination of DOE proposed rule changes along with "incentives rather than subsidies"

Quotes and paraphrasing of Perry's comments re FERC letter

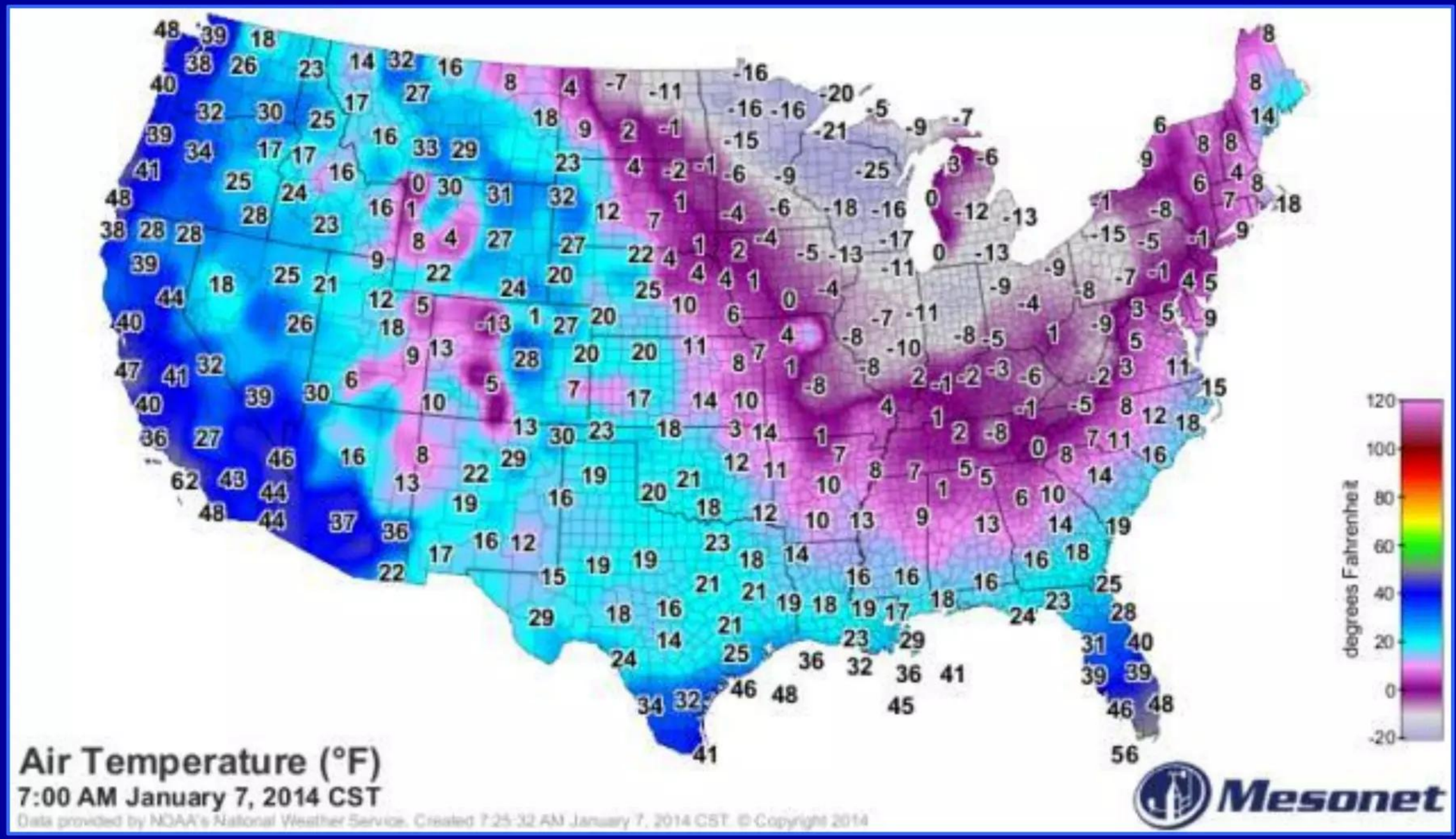
Said 2014 polar vortex showed need for uninterruptible power generation

Came within one dispatchable power plant of East Coast blackout during event

- Perry cited "polar vortex of 2014" as good example of unusual weather event that demonstrates great value of dispatchable and *uninterruptible* grid power generation assets. Dispatchable generation can be used to minimize or eliminate disruptions in grid's ability to deliver 99+ % reliable electric power to consumers by increasing resiliency of electric power generation to outages from greatly protracted episodes of bad weather
- In subsequent discussion, Perry and certain committee members noted that during 2014 polar vortex, electric power production from certain NE U.S. natural gas plants was curtailed because of gas pipeline capacity constraints that were unable to simultaneously satisfy high demand from power plants vs. from residential heating customers trying to warm homes
- Re performance of dispatchable generation assets during 2014 polar vortex event: committee member David McKinley recalled that, "We came within one smaller [coal-fueled] power plant of a blackout across the entire East Coast." He further noted that 55% of generation capacity loss in event came from gas-fired power plants 'starved' by pipeline capacities

Temperatures at 7:00 AM on Jan. 7, 2014 during polar vortex

Extremely cold air temperatures affected almost the entire United States



Lake Michigan breakwater: Chicago, IL in 2014 polar vortex

NERC's review of 2014 polar vortex cold weather event

Period of extraordinarily cold U.S. temperatures lasted less than a week

If longer-duration vortex event occurred gas supply interruptions could be worse

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Polar Vortex Review

September 2014

http://www.nerc.com/pa/rrm/January%202014%20Polar%20Vortex%20Review/Polar_Vortex_Review_29_Sept_2014_Final.pdf

"This report describes what happened during the polar vortex and why some of the conditions occurred, and it presents lessons learned and recommendations for future actions. In early January of 2014, the Midwest, South Central, and East Coast regions of North America experienced a weather condition known as a polar vortex, where extreme cold weather conditions occurred in lower latitudes than normal, resulting in temperatures 20 to 30° F below average. Some areas faced days that were 35° F or more below their average temperatures. These temperatures resulted in record high electrical demand for these areas on January 6 and again on January 7, 2014."

"During the polar vortex, the cold weather also increased demand for natural gas, which resulted in a significant amount of gas-fired generation being unavailable due to curtailments of gas."

NERC's review of 2014 polar vortex cold weather event

Major impact on gas-fired generation was interruption of fuel supplies

"The most significant impacts to the BPS in the MRO Region began on January 5, 2014, and persisted through January 7, 2014. The extremely cold temperature was the primary impacting factor, but heavy precipitation also affected large portions of the Region. Temperatures in many areas were the lowest experienced in 20 years. Minneapolis, where the average high for early January is 23° F, experienced 62 consecutive hours below 0° F from January 5 to January 7. As the polar vortex extended south and east, it also began to impact the SPP, TRE, RF, SERC, and NPCC Regional Entities. As a result, the majority of the Eastern and ERCOT Interconnections experienced similar variances from normal."

"One of the largest issues impacting gas-fired generation was the curtailment or interruption of fuel supply. Unlike other fuel sources, natural gas is not typically stored on-site. Generators rely on real-time delivery of natural gas from their suppliers. When units are not confident that they will be dispatched, the fuel is often obtained on the spot-market on a non-firm, interruptible basis. Therefore, if firm contracts are honored before interruptible contracts, if the firm customers require more gas, and the capacity of the gas transportation is based on firm contracts, less capacity is available for interruptible supply. This can result in generating units becoming unavailable as there is no pipeline capacity to supply interruptible gas [to gas-fired power plants]."

Quotes and paraphrasing of Perry's comments re FERC letter

Believes that there's no such thing as a truly free market in electricity

Grid generation capacity must be resilient under worst-case weather events

Perry responded to criticisms that DOE-proposed FERC rule changes would: (a) greatly interfere with "free competition" across U.S. electricity markets as compared to how they operated during 8 years of President Obama's presidency and (b) unnaturally prevent closing of aging nuclear and coal-fired power plants:

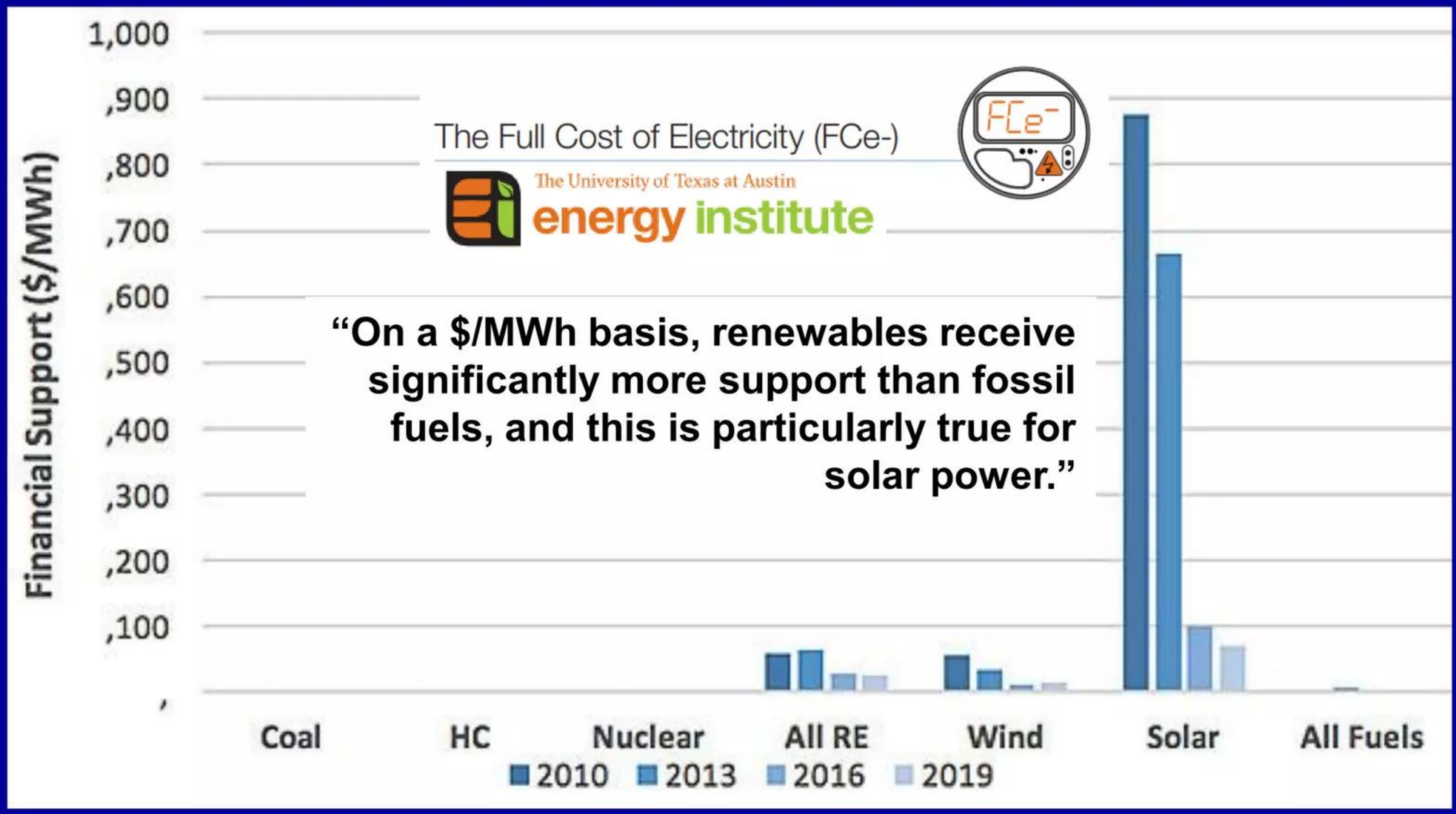
- Perry said there is no such thing as a perfect "free market in electricity" and that "Obama put his thumb on the scale" with a regulatory environment and subsidies bias that strongly favored new grid generation capacity dominated by renewable energy sources and natural gas; coal and nuclear languished
- Perry noted that electric power generation and electricity markets "are highly regulated" and moreover have always been that way. He said that his guiding philosophy in an imperfect, real world of regulation is that one should strive to "make it as fair as you can" subject to key constraint that --- e.g. worst-case, longer-duration future polar vortex event --- "I don't want to bet that the lights will stay on" or chose between "turning the lights on versus keeping families warm." "I don't want to scare the American public about what could happen in a bad polar vortex." What would happen if such an event lasted 1 - 2 months?
- Natural gas plant outages in 2014 polar vortex made Perry uncomfortable with having inadequate reserve capacity from uninterruptible nuclear & coal plants

Obama administration 2008 - 2016 had "thumb on the scale"

Regulatory environment and $$$ subsidies strongly favored renewables

White paper: "Federal financial support for electricity generation technologies"

UT Austin (2017) – Fig. 4 "Per-megawatt-hour subsidy by type and fuel" (US$/MWh)



https://spectrum.ieee.org/energywise/energy/policy/how-much-does-the-us-government-subsidize-electricity-generating-technologies

https://live-energy-institute.pantheonsite.io/sites/default/files/UTAustin_FCe_Subsidies_2017_June.pdf

Quotes and paraphrasing of Perry's comments re FERC letter

Only nuclear & coal able to provide uninterruptible power in cold weather

Over 200 million people in U.S. saw extreme cold at height of 2014 polar vortex

- Absent new types of special financial incentives that are adequate to keep some aging dispatchable power plants operating, Perry and DOE are very concerned that additional closures of important uninterruptible nuclear and coal reserve baseload generation capacity could very adversely affect U.S. grid's ability to withstand future weather events like 2014 polar vortex or worse without experiencing long, economically and societally unacceptable electric power outages. Cost of keeping these plants open is like insurance
- At height of 2014 polar vortex event, over 200 million people in U.S. were affected by several days of extremely low temperatures and cloudy skies
- Requirement for 90-day fuel supply not justified in detail; however, given that coldest part of 2014 polar vortex only lasted several days, Perry and DOE may have thought requiring 90 days of fuel supplies kept onsite would be an adequate margin of temporal safety so that nuclear and coal plants would be able to provide U.S. grids with essentially uninterruptible electric power for duration of any reasonable worst-case weather event scenario
- Depending on position in fuel-cycle, nuclear plants can generate power for up to 18 - 24 months; not too onerous for coal plants to store 90 days of fuel

Quotes and paraphrasing of Perry's comments re FERC letter

Not climate denier - Perry wants to better prepare grid for climate change

DOE/Perry directive to FERC aims to boost U.S. grid resiliency to future weather

- DOE's guiding philosophy is for future U.S. grid to be supported by well-diversified mixture of different types of dispatchable and non-dispatchable power generation assets that altogether can provide 99+ % uptime availability in plausible worst-case weather scenarios
- Acknowledged possibility that such a desired level of grid reliability might ultimately cost more than future alternative lowest-possible-cost grid generation mixtures that could have much higher % of non-dispatchable renewables and natural gas but less resiliency. Such additional cost can be conceptualized as a U.S. "insurance policy" against future possibility of severe weather-related power outages
- Many special interests protested about requested, atypically short period for public comment of 60 days, after which FERC would finally "conclude its rulemaking" with regard to DOE/Perry's new proposal. Customary period for such comments is 90 days. One can speculate that DOE's urgency in quickly obtaining a ruling was simply because U.S. winter begins on Dec. 21, less than 90 days away --- there is no guarantee that a severe polar vortex event could not happen by then

Sept. 2017 IHS report supports logic of Perry/DOE proposal

"U.S. is moving toward less reliable, less resilient power generation mix"

IHS Markit — IHS Markit Resilient and Efficient Electricity Generation Special Report

"Ensuring resilient and efficient electricity generation: the value of the current diverse U.S. power supply portfolio" by L. Makovich & J. Richards, Sept. 2017

"IHS Markit report: eroding cost effective diversity in U.S. power grid will result in greater price fluctuations, higher power bills and create negative impacts throughout the economy"

"Ability to reduce the magnitude and duration of disruptive events is often taken for granted and is at increasing risk of eroding. The grid-based electricity supply portfolio in the United States is becoming less cost-effective, less reliable, and less resilient owing to a lack of harmonization between federal and state energy policies and wholesale electricity market operations. Policy-driven market distortions are delaying market adjustments to achieve a reliable long-run demand and supply balance, suppressing market-clearing wholesale electricity prices and reducing market-based generator cash flows. Consequently, some power plants that are critical to maintaining reliable, resilient, and efficient electric supply are retiring before it is economic to do so; and this acceleration in the turnover of the US electric supply portfolio is moving the United States toward a less cost-effective, less reliable, and less resilient power generation mix."

Sept. 2017 IHS report supports logic of Perry/DOE proposal

Premature retirements of fuel-secure baseload power reduces resilience

IHS Markit — IHS Markit Resilient and Efficient Electricity Generation Special Report

"The nation's electric reliability watchdog, the North American Electric Reliability Corporation [NERC], observed, 'Premature retirements of fuel secure baseload generating stations reduces resilience to fuel supply disruptions'. Within the next decade, a 'less efficient diversity' portfolio case could characterize some US power systems. Such a case involves no meaningful contributions from coal or nuclear resources, a smaller contribution from hydroelectric resources, and a tripling of the current 7% contributions from intermittent resources, with the remaining majority of generation coming from natural gas-fired resources. This less efficient diversity portfolio case also likely results in little or no reduction in electric sector carbon dioxide (CO_2) emissions because the CO_2 emissions profile of the prematurely retiring power supply resources is less than or equal to the emissions profile of the replacement power resources."

https://www.ihs.com/Info/0917/electricity-generation-special-report.html

https://www.globalenergyinstitute.org/sites/default/files/Value%20of%20the%20Current%20Diverse%20US%20Power%20Supply%20Portfolio_V3-WB.PDF

John Kemp of Reuters published excellent summary article

"Fuel security is crux of argument made by … Rick Perry … for new rule"

"Fuel security and power generation in the United States"

By John Kemp for *Reuter's* October 17, 2017 at 11:37 AM

https://www.reuters.com/article/usa-electricity-kemp/column-fuel-security-and-power-generation-in-the-united-states-kemp-idUSL8N1MS60S

" 'During the polar vortex, the cold weather also increased demand for natural gas, which resulted in a significant amount of gas-fired generation being unavailable,' NERC wrote in a post-event study."

"Many generators failed to start or were unable to operate at full capacity, leading to intense pressure on electricity supplies, although almost no firm load was disconnected. Many units failed because of frozen equipment but at least some were unavailable due to fuel supply problems and the problem was especially pronounced for gas-fired units."

"Gas-fired generators accounted for 55 percent of forced outages during the vortex, even though they represented only 40 percent of capacity in the impacted areas. By contrast, coal-fired units accounted for 26 percent of outages and 31 percent of capacity, while nuclear generators suffered 3 percent of the outages but provided 12 percent of capacity."

"Fuel supply proved especially problematic in the Mid-Atlantic and Great Lakes areas, where more than 10,000 megawatts of capacity was hit at the worst point."

Probability of severe polar vortex events could be increasing

New paper: climate change could be boosting likelihood of cold episodes

"Think winters are getting colder? Blame Arctic warming and, yes, the polar vortex"

Mashable By Andrew Freedman for *Mashable* Sept. 22, 2017 Mashable

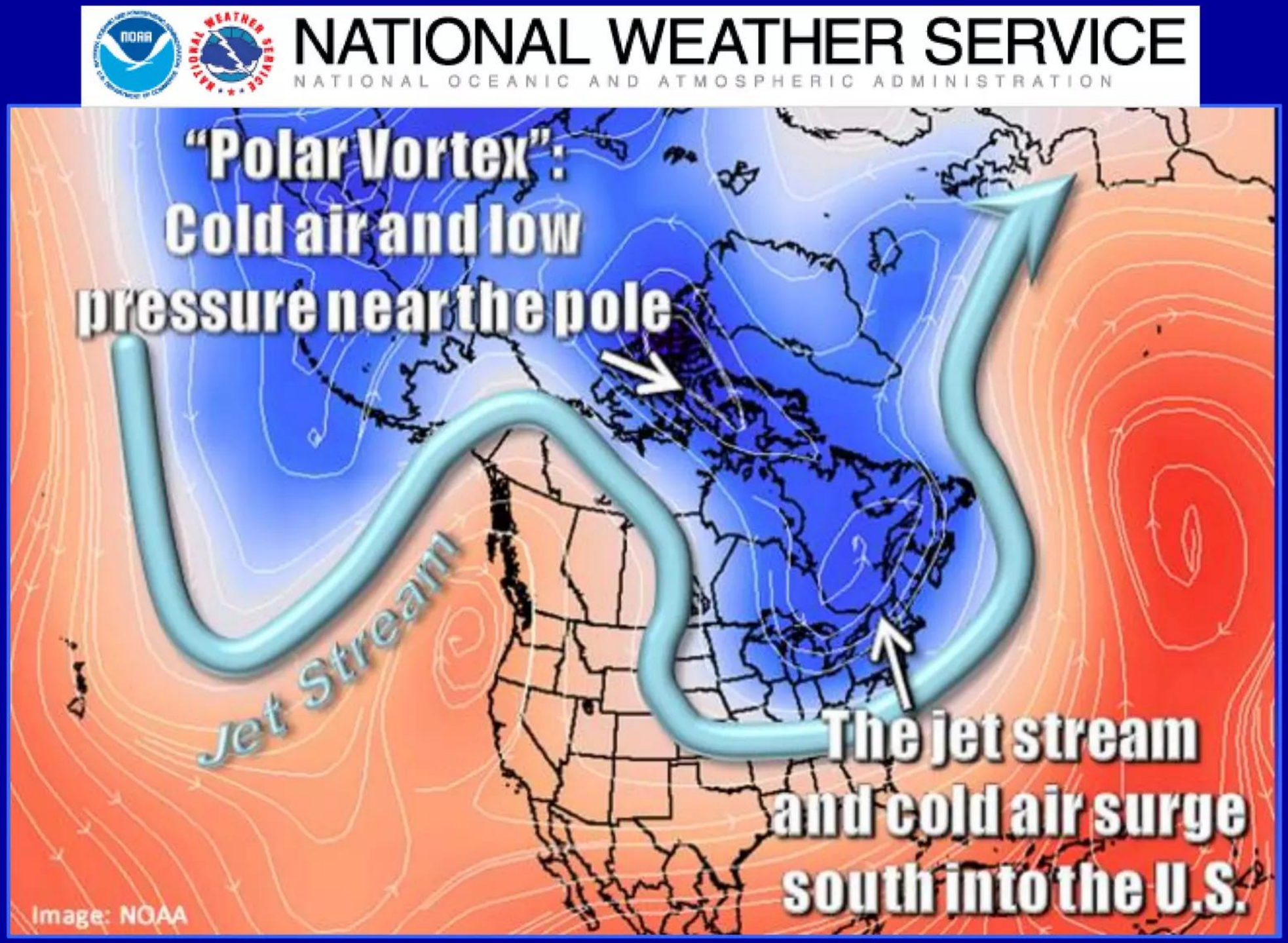
http://mashable.com/2017/09/22/polar-vortex-study-climate-change-arctic-warming-colder-winters/#jzudu4.HWkq6

"There is growing scientific support for one of the most provocative and counterintuitive ideas in climate change research, which holds that rapid Arctic warming may be causing colder winters across large swaths of the Northern Hemisphere."

"A new study, to be published in the journal *Bulletin of the American Meteorological Society*, found that a weakening polar vortex, potentially set in motion by the rapidly warming and melting Arctic, has become more common during the past four decades. This results in colder winters across large regions of Europe and Russia, but also occasionally in the U.S. as well."

"The study is the first to show that changes in winds in the stratosphere substantially contributed to a mysterious winter cooling trend in northern Europe and Asia, including a region already known for being frigid: Siberia."

How polar vortex events create cold snaps in lower 48 states



http://www.nws.noaa.gov/om/cold/polar_vortex.shtml

Probability of severe polar vortex events could be increasing

New paper: climate change may be boosting likelihood of cold episodes

"More-persistent weak stratospheric polar vortex states linked to cold extremes"
M. Kretschmer et al. *Bulletin of the American Meteorological Society* Sept. 22, 2017

http://journals.ametsoc.org/doi/pdf/10.1175/BAMS-D-16-0259.1

"Over the last decades, the stratospheric polar vortex has shifted towards more frequent weak states which can explain Eurasian cooling trends in boreal winter in the era of Arctic amplification. The extra-tropical stratosphere in boreal winter is characterized by a strong circumpolar westerly jet, confining the coldest temperatures at high latitudes. The jet, referred to as the stratospheric polar vortex, is predominantly zonal and centered around the pole; however, it does exhibit large variability in wind speed and location. Previous studies showed that a weak stratospheric polar vortex can lead to cold-air outbreaks in the mid-latitudes, but the exact relationships and mechanisms are unclear. Particularly, it is unclear whether stratospheric variability has contributed to the observed anomalous cooling trends in mid-latitude Eurasia ... we show that over the last 37 years, frequency of weak vortex states in mid to late winter (January and February) has increased which were accompanied by subsequent cold extremes in mid-latitude Eurasia. For this region 60% of the observed cooling in the era of Arctic amplification, i.e. since 1990, can be explained by the increased frequency of weak stratospheric polar vortex states, a number which increases to almost 80% when El Niño/Southern Oscillation (ENSO) variability is included as well."

Latest science supports Perry/DOE's concern re fuel security

Probability of polar vortex-related winter cold snaps may be increasing

Maybe DOE suggestions are reasonable when you get past energy politics?

- Ongoing climate change appears to be increasing the probability of extreme polar vortex cold snaps like what occurred in U.S. in winter of 2014; lowest temperatures during that episode only lasted for several days. Since then, there have been additional occurrences of weather extremes that drastically reduced renewable power output and lasted much longer than several days
- During 2015 there was a severe wind drought in Western United States *lasting six months* ; see Lattice PowerPoint dated March 2, 2016 cited later herein
- During December 2016 and January 2017 Germany and Western Europe experienced several protracted periods --- *lasting up to one month* --- during which there was little or no sun nor any wind. On January 24, power shortfall with renewables got so bad that Germany came within one dispatchable coal-fired power plant of experiencing a national power blackout. That was eerily similar to what nearly happened in Northeastern U.S. during worst of 2014 polar vortex and revealed limited resilience of Germany's *Energiewende* ; see Lattice PowerPoints dated February 10 and April 19, 2017 cited later herein
- Given that extreme weather events can clearly cause substantial, protracted power shortfalls with renewables and natural gas plants, Rick Perry/DOE's deep concerns about fuel security and suggestions to FERC are reasonable

Germany almost had a national blackout on January 24, 2017

Lattice PowerPoint presentation covering this published April 19, 2017

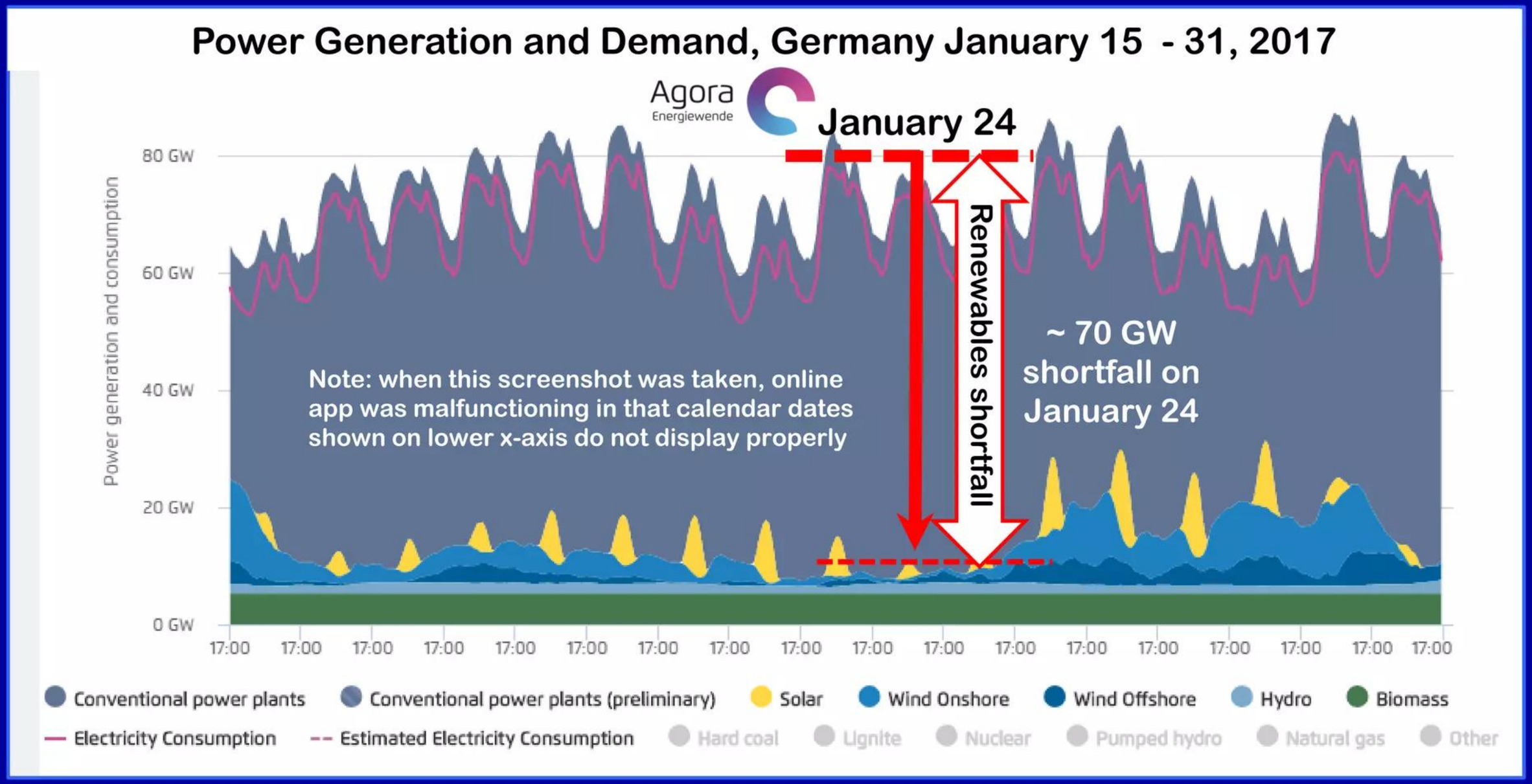
See presentation at URL below for details and source documents: 25 slides

https://www.slideshare.net/lewisglarsen/lattice-energy-llc-excessive-reliance-on-renewable-energy-sources-can-threaten-reliability-of-electricity-grids-april-19-2017

Germany almost had a national blackout on January 24, 2017

Cloudy, windless weather in Germany slashed renewable power output

Rheinische Post: last reserve power plant brought online to avert a blackout



Original main title of news story: “Deutsches Stromnetz schrammt am Blackout vorbei”

Composite translation of text: “German electricity network barely avoids a blackout”

http://www.rp-online.de/wirtschaft/unternehmen/deutsches-stromnetz-schrammt-am-blackout-vorbei-aid-1.6636489

Germany almost had a national blackout on January 24, 2017

No blackout happened because FNA "took the last reserve power plant"

"Too little wind and sun - German electricity network barely avoids a blackout"
By C. Longin and M. Plück in *Rheinische Post* (RP) on February 27, 2017

http://www.rp-online.de/wirtschaft/unternehmen/deutsches-stromnetz-schrammt-am-blackout-vorbei-aid-1.6636489

Translation of original German to English by Google; text below is directly quoted from news article

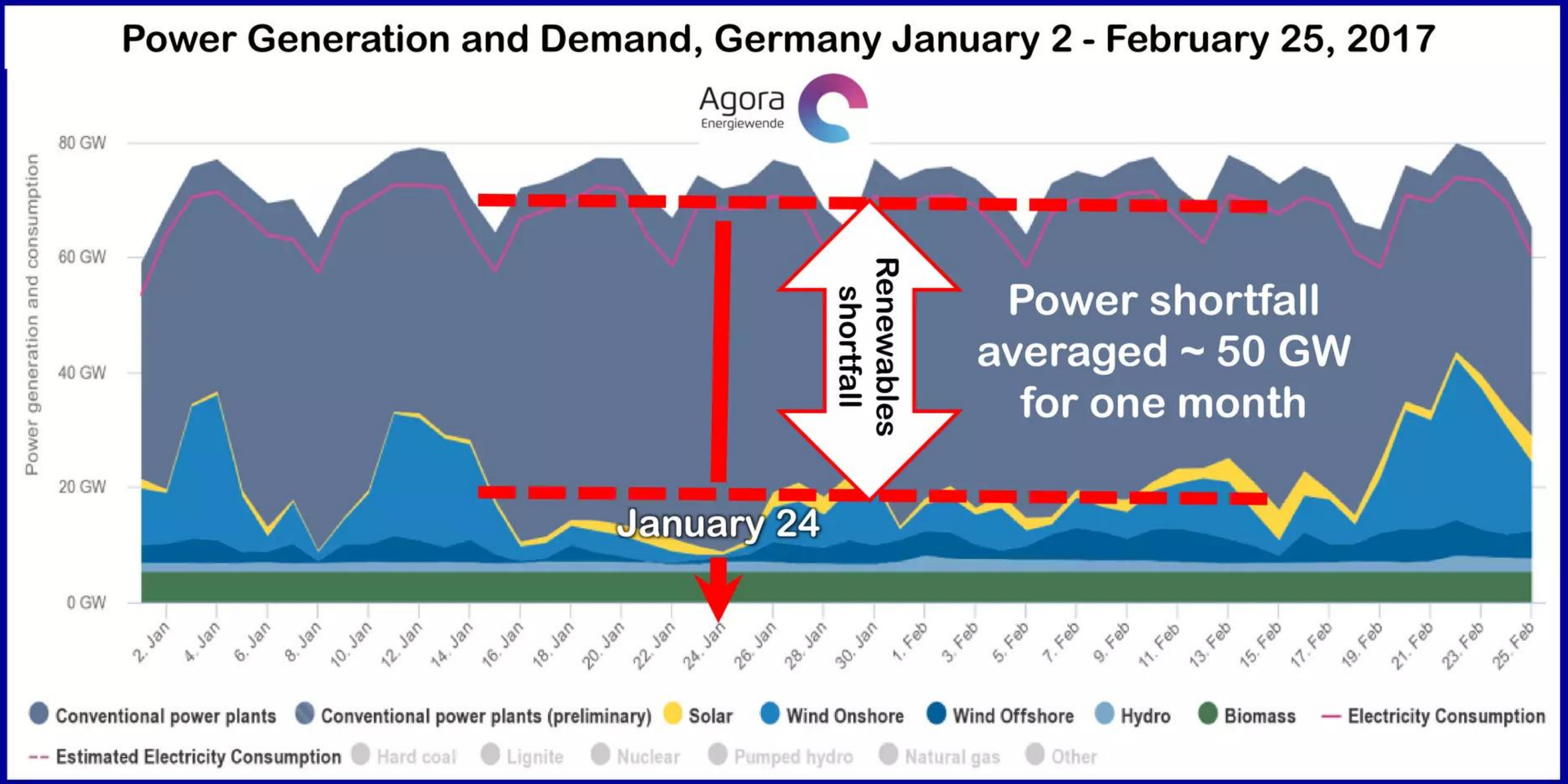
"According to Michael Vassiliadis, head of IG Bergbauchemie Energie, the situation on 24 January was critical: on that day, energy companies and network operators could only have been able to maintain the electricity supply with great difficulty, the trade unionist told journalists at an event in Haltern am See. Despite the problems, the Germans demanded more than 80 gigawatts of power, as on other days. 'The renewables could not even offer five percent,' said Vassiliadis."

"According to Vassiliadis, the fact that a blackout did not take place there was only because the German energy suppliers 'also took the last reserve power plant.' Coal, gas and nuclear power kept the country almost in the first place under the electric current.' On request, the Federal Network Agency [FNA] did not comment on the network overload."

Germany almost had a national blackout on January 24, 2017

~ 50 GW shortfall of renewables vs. total demand lasted about one month

Battery storage cost to cover > 50 GW shortfall for month prohibitively high $



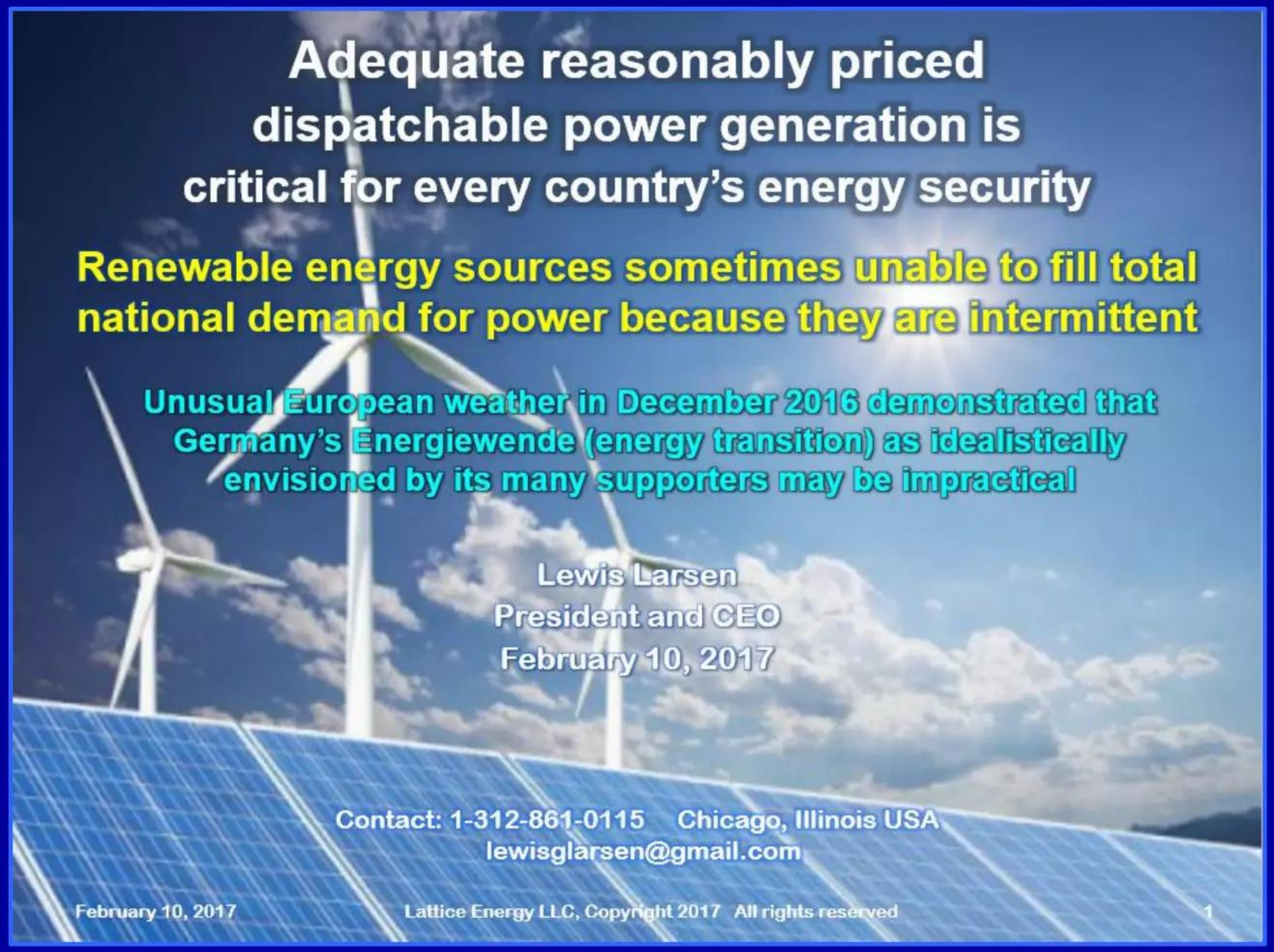
100% renewable energy sources + enormous grid storage capacity would be far too expensive and cause unreliability; not cost-effective for future grids

Dec. 2016: Germany's renewable power output slashed twice

Lattice PowerPoint presentation covering this published Feb. 10, 2017

See presentation at URL below for details and source documents: 95 slides

http://www.slideshare.net/lewisglarsen/lattice-energy-llc-adequate-reasonably-priced-dispatchable-power-generation-critical-to-national-energy-security-feb-10-2017

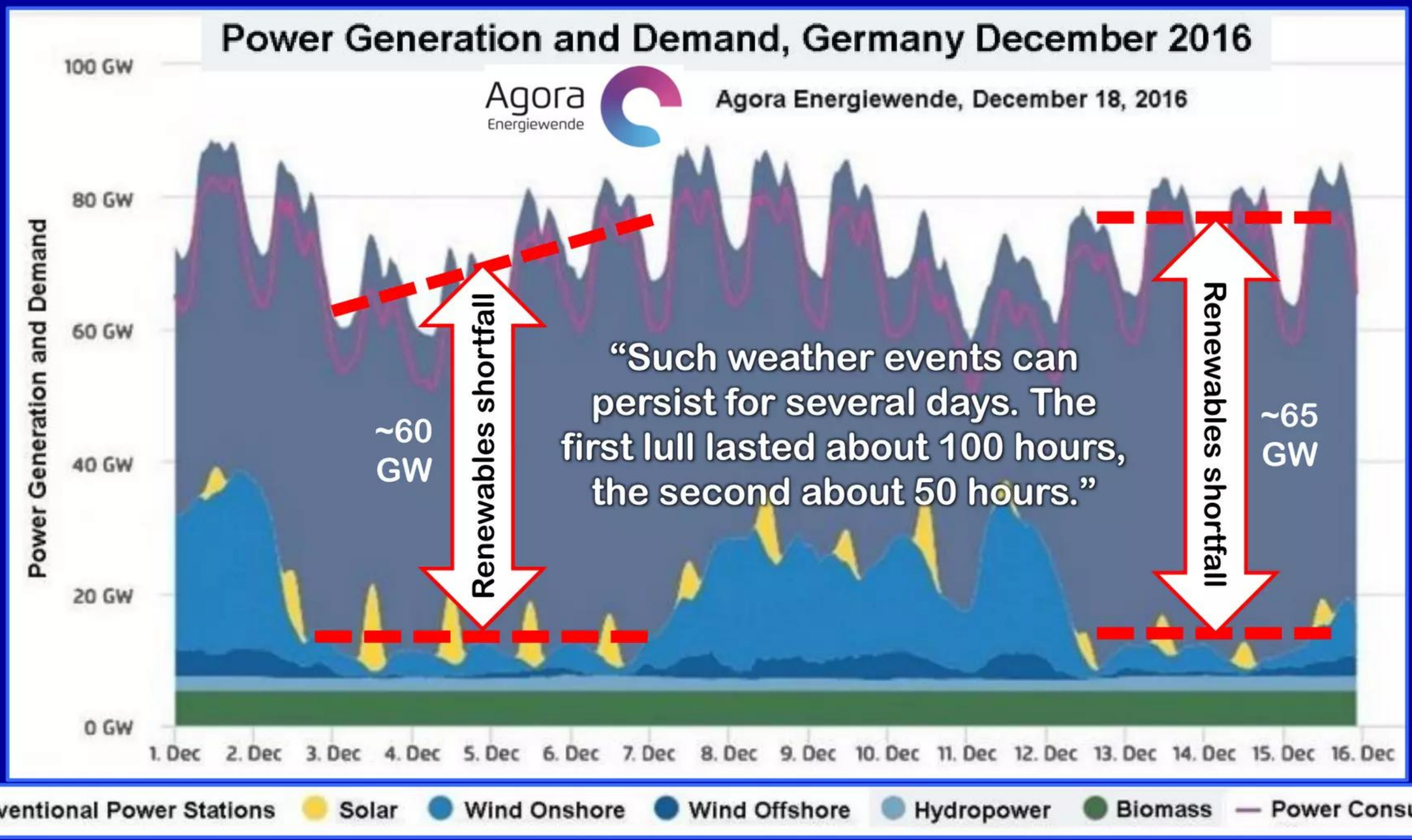


Dec. 2016: Germany's renewable power output slashed twice

Lattice PowerPoint presentation discussing this published Feb. 10, 2017

First lull in power production lasted 100 hours; second shortfall lasted 50 hours

Big shortfalls in German renewable power production occurred 2x in one month

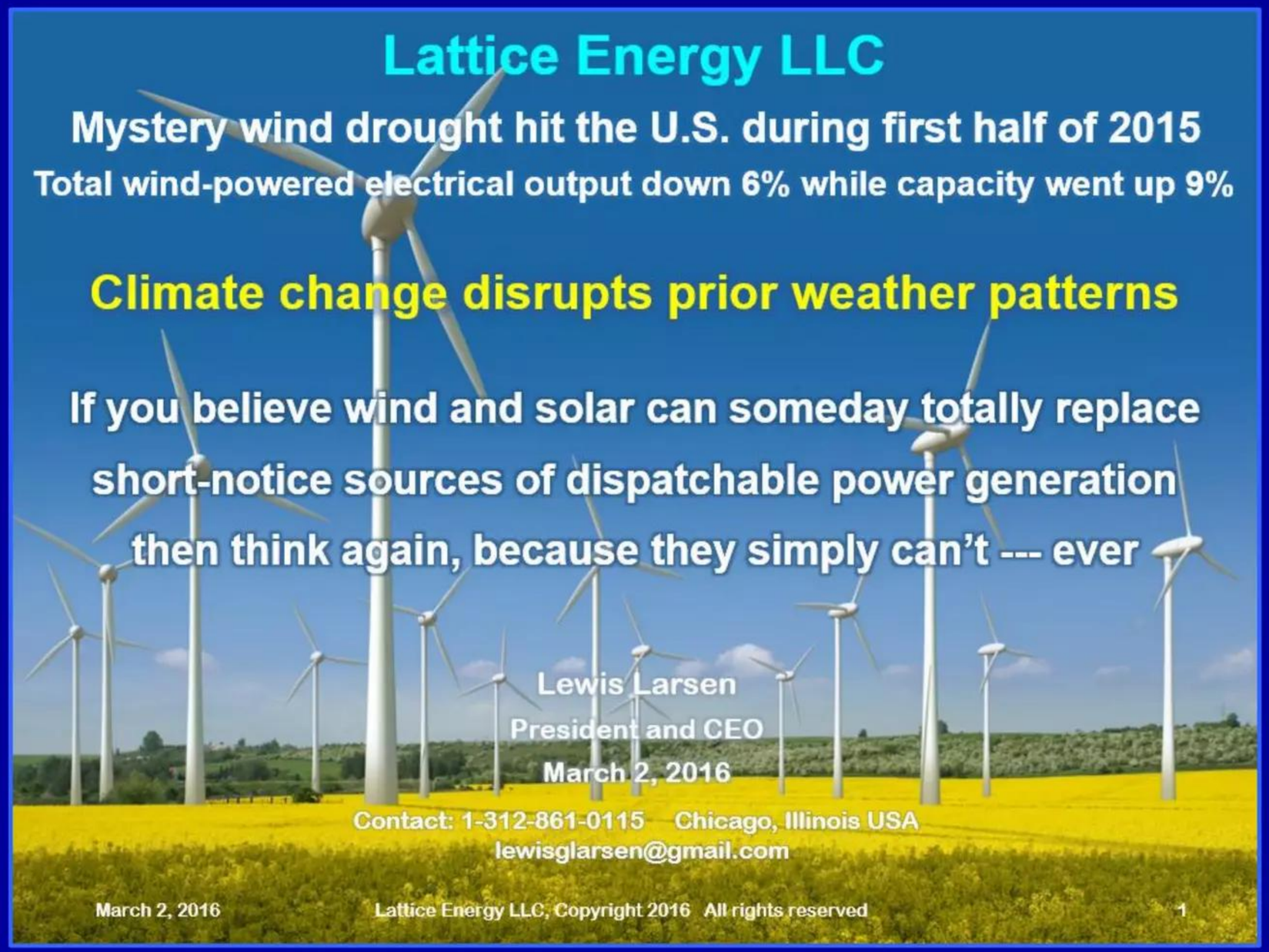


U.S. West Coast wind drought lasted for 6 months in 2015

Lattice PowerPoint presentation covering this published Mar. 2, 2016

See presentation at URL below for details and source documents: 66 slides

http://www.slideshare.net/lewisglarsen/lattice-energy-llc-climate-change-can-reduce-wind-and-solar-power-output-also-need-dispatchable-generation-march-2-2016



U.S. West Coast wind drought lasted for 6 months in 2015

Wind speeds in certain states reduced up to 20% below long term mean

DNV·GL

"Whither the winds in 2015? Analysis of the anomalously low winds in the U.S." Doc. #108917-RT-01-A Feb. 12, 2016

https://www.dnvgl.com/news/dnv-gl-study-el-nino-not-cause-of-2015-wind-drought--57798

"During the first half of 2015, large swaths of the United States (U.S.) experienced anomalously low winds, whose geographic extent and longevity eclipses any similar event in recent history. Ebbs in windiness are of course commonplace, driven by the passage of weather systems - some fair, some stormy - but rarely do so such lulls last beyond a few days. A number of claims and hypotheses have been made about the connection between the low winds and various climatic drivers - some are highly speculative. Unfortunately, such claims greatly outnumber established results. To help remedy this situation, this note attempts to illuminate the characteristics of the anomalous winds and, through careful quantitative analysis, offers one plausible explanation for their origin … wind speeds over much of the U.S. ranged from 6% below the long term mean to a deficit as high as 20%. Over California, Oregon, Washington, Nevada, Arizona, southeast Texas, and Florida, these are the lowest observed wind speeds within the entire 1979-present record. However, other regions were not nearly as affected, particularly the Great Plains which has a large installed capacity of operating wind farms. By mid-year, the winds returned to their more normal patterns of variability. It is natural to seek the root causes of this event, and to determine whether we will ever witness a so long-lived and so significant event in the future."

U.S. West Coast wind drought lasted for 6 months in 2015

Image shows departure from mean wind speeds for first half of 2015

Darkest shade of blue indicates greatest value for deviation from mean = ~21%

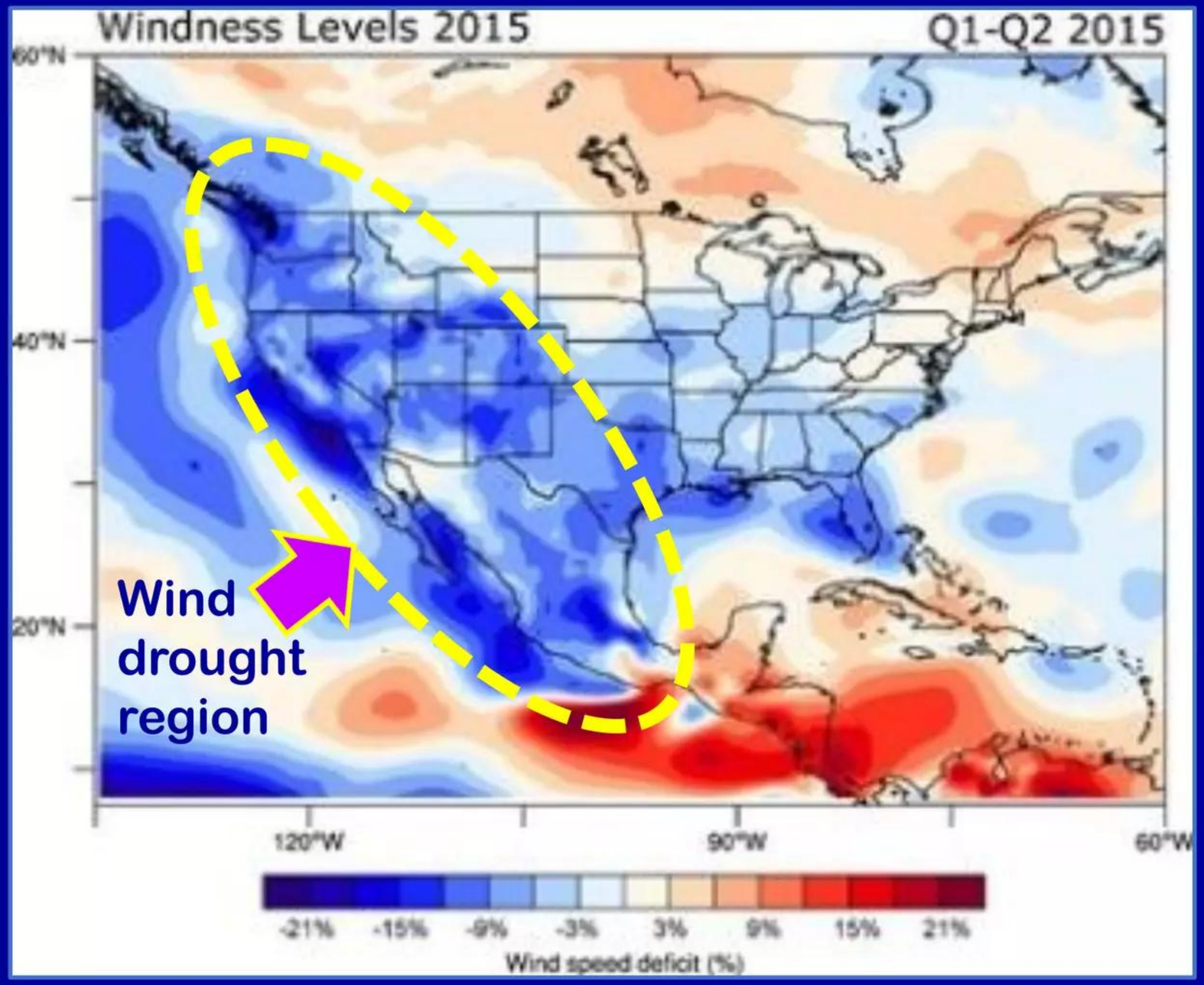


Fig. 2-1 in DNV-GL report "Whither the winds in 2015?"

Data source: NASA (generated from MERRA)

What will happen to weather in U.S. beyond October of 2017?

Most likely time for polar vortex event would be January - February 2018

"Waves of chilly air to bring opportunities for snow in midwestern and perhaps northeastern US"

October 23, 2017 at 11:06 AM: "Waves of chilly air will bring opportunities for snowflakes and accumulating snow in parts of the central and northeastern United States through the end of October. While cooler air will reach the Atlantic coast, the main thrust of chilly air and greatest chance of snow is likely over the Central states in the short term," according to AccuWeather Lead Long-Range Meteorologist Paul Pastelok. The waves of chilly air will deliver the lowest temperatures of the season so far to many portions of the Plains and the Midwest during the next five to seven days."

https://m.accuweather.com/en/weather-news/waves-of-chilly-air-to-bring-opportunities-for-snow-in-midwestern-and-perhaps-northeastern-us/70003079

Working with Lattice Energy LLC

Partnering on commercialization and consulting on certain subjects

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L. Larsen c.v.: http://www.slideshare.net/lewisglarsen/lewis-g-larsen-cv-june-2013

- We believe Lattice is the world-leader in proprietary knowledge about LENR device engineering required to develop high-performance, long lived, scalable power sources. Our published peer-reviewed theoretical papers rigorously explain the breakthrough device physics of LENR processes, including the absence of dangerous energetic neutron or gamma radiation and lack of long-lived radioactive waste production
- Lattice welcomes inquiries from large, established organizations that have an interest in discussing the possibility of becoming Lattice's strategic capital and/or technology development partner
- Lewis Larsen also independently engages in consulting on variety of subject areas that include: Lithium-ion battery safety issues; long-term electricity grid reliability and resilience; and evaluating potential future impact of LENRs from a long-term investment risk management perspective for large CAPEX projects in the oil & gas, petrochemicals, transportation, utility, and aerospace industries