

رأببـرت بـرأببـس بـرق و ثـروت مـلل

چالش‌های اقتصادی انرژی و محیط زیست

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بنگاه ترجمه و نشر
کتاب پارسه

یادداشت‌ها

مقدمه: محله فقیر آنتون روئز

۱. به نقل از بن جمان، «با هدف غیرانتفاعی کمک به آفریقا تا انرژی برای توسعه اقتصادی تهیه کند.»

Axios, February 26, 2019, www.axios.com/startup-africa-energy-manufacturing-economy-power-35e46508-3bd3-4f0c-a48c-64e534599933.html

۲. مدتی بعد مصرف سرانه برق خانواده را حدود ۱۳۰۰ کیلووات-ساعت در سال محاسبه کردم. این میزان مصرف برق تقریباً برابر با برق مصرفی یک خانوار معمولی در کشورهایی مانند پرو یا کلمبیا است.

۳. مقایسه گروه رودیوم از محاسبه تعداد کل ساعتی که مشتری بی برق به سر برده بود به دست آمد.

4. Trevor Houser and Peter Marsters, "The World's Second Largest Blackout," Rhodium Group, April 12, 2018, <https://rhg.com/research/puerto-rico-hurricane-maria-worlds-second-largest-blackout/>.
5. Wikipedia, s.v. "Solar Storm of 1849," last modified April 9, 2019, 06:38, https://en.wikipedia.org/wiki/Solar_storm_of_1859.
6. Deborah Byrd, "\$40 Billion a Day for Solar Super-Storms," *EarthSky*, January 20, 2017, <http://earthsky.org/earth/40-billion-a-day-for-solar-super-storms>.
7. Rebecca Smith, "Russian Hackers Reach U.S. Utility Control Rooms,

Homeland Security Officials Say,” *Wall Street Journal*, July 23, 2018, www.wsj.com/articles/russian-hackers-reach-u-s-utility-control-rooms-homeland-security-officials-say-1532388110.

8. “Recognizing the Duty of the Federal Government to Create a Green New Deal” H.R. Res 109, 116th Cong. (2019), www.congress.gov/bill/116th-congress/house-resolution/109/text.

۹. در انتهای سال ۲۰۱۸، آمازون مالک یا کنترل‌کننده حدود ۴/۷۰۰ مگاوات ظرفیت تولید برق بود. برای مقایسه، کرواتسی حدود ۴/۹۰۰ مگاوات و لائوس حدود ۴/۵۰۰ مگاوات ظرفیت برق داشت. بنگرید به

“Country Comparison: Electricity—Installed Generating Capacity,” CIA World Factbook, www.cia.gov/LIBRARY/publications/the-world-factbook/rankorder/2236rank.html.

10. *BP Statistical Review of World Energy 2018* (London: BP, 2018).

تولید جهانی برق در فاصله ۱۹۸۵ تا ۲۰۱۵ به میزان ۱۴۵ درصد افزایش یافت. بنابراین، تولید برق بیش از دو برابر سریع‌تر از مصرف نفت رشد کرد که طی آن دوره ۶۰ درصد رشد کرده بود. تولید برق همچنین سریع‌تر از رشد مصرف زغال سنگ (۸۵ درصد)، گاز طبیعی (۱۱۱ درصد) و هسته‌ای (۷۴ درصد) رشد کرد.

۱۱. کل درآمدهای جهانی سالانه نفت و گاز حدود ۲/۹ تریلیون دلار است. این برآورد براساس گزارش *BP Statistical Review of World Energy 2018* به‌دست آمده است که مصرف جهانی نفت روزانه ۹۸ میلیون بشکه و مصرف گاز طبیعی روزانه حدود ۶۳ میلیون بشکه معادل نفت است. کل مصرف نفت و گاز حدود ۵۹ میلیارد دلار بشکه معادل نفت در سال است. با قیمت پنجاه دلار هر بشکه، از این مصرف به فروش سالانه ۲/۹ تریلیون دلار می‌رسیم. ۱۲. مجموع فروش برق امریکا در سال ۲۰۱۷ رقم ۳۹۰ میلیارد دلار بود. بنگرید به اداره اطلاعات انرژی

“Revenue from Sales of Electricity to Ultimate Customers,” www.eia.gov/electricity/annual/html/epa_02_06.html.

امریکا که حدود ۴/۲۰۰ تراوات - ساعت برق در سال تولید می‌کند تقریباً ۱۶ درصد تولید جهانی به حساب می‌آید. بنابراین شش ضریب چهارصد میلیارد دلار، برابر با ۲/۴ تریلیون دلار می‌شود.

۱۳. در سال ۲۰۱۶، کل فروش سالانه خودرو حدود ۸۴ میلیون واحد بود. اگر بهای هر خودرو را ۲۵ هزار دلار در نظر بگیریم صنعت خودرو حدود ۲.۱ تریلیون دلار درآمد داشت. برای داده‌های فروش خودرو بنگرید به:

“Global Car Sales Up by 5.6% in 2016 Due to Soaring Demand in China, India and Europe,” JATO, February 9, 2017, www.jato.com/usa/global-car-sales-5-6-2016-due-soaring-demand-china-india-europe/.

برای میانگین قیمت خودروهای جدید بنگرید به

“China’s Got Sales, U.S. Has Riches,” *Automotive News*, March 16, 2015, www.autonews.com/article/20150316/RETAIL01/303169975/chinas-got-sales-u.s.-has-riches.

درآمد سالانه کسب‌وکار جهانی دارو حدود یک تریلیون دلاری است. بنگرید به

Business Research Company, “The Growing Pharmaceuticals Market: Expert Forecasts and Analysis,” *Market Research Blog*, May 16, 2018, <https://blog.marketresearch.com/the-growing-pharmaceuticals-market-expert-forecasts-and-analysis>.

14. Energy Information Administration, “Revenue from Sales of Electricity to Ultimate Customers.”

۱۵. در ۲۰۱۸، درآمد این سه شرکت به شرح زیر گزارش شد: فورد ۱۶۰/۳ میلیارد دلار، جنرال الکتریک ۱۲۱/۶ میلیارد دلار، جنرال موتورز ۱۴۷ میلیارد دلار. مجموع ۴۲۸/۹ میلیارد دلار.

16. “Global Greenhouse Gas Emissions Data,” Environmental Protection Agency, www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data.

17. Vaclav Smil, “Moore’s Curse and the Great Energy Delusion,” *The American*, November 19, 2008, www.aei.org/publication/moores-curse-and-the-great-energy-delusion/.

فصل ۱. مبانی برق

1. Erin Wayman, “The Earliest Evidence of Hominid Fire,” *Smithsonian.com*, April 4, 2012, www.smithsonianmag.com/science-nature/the-earliest-example-of-hominid-fire-171693652/.

۲. یک روز از $۸۶/۴۰۰$ ثانیه تشکیل می‌شود. اگر $۴۰۰/۰۰۰$ سال = $۸۶/۴۰۰$ ثانیه باشد
 آنگاه یک سال = $۰/۲۱۶$ ثانیه است. بنابراین ۱۴۰ سال عصر برق به اندازه $۳۰/۲۴$ ثانیه
 طول می‌کشد.

3. "Electric Current," SI Units Explained, www.si-units-explained.info/ElectricCurrent/#.WESLOHeZPNw.
4. Independence Hall Association, "Electricity," The Electric Ben Franklin, USHistory.org, www.ushistory.org/franklin/science/electricity.htm. "Benjamin Franklin," APS Physics, www.aps.org/programs/outreach/history/historicsites/franklin.cfm.
5. William Beatty, "How Are Watts, Ohms, Amps, and Volts Related?" April 2, 2000, <http://amasci.com/elect/vwatt1.html>.
۶. از جان‌تان لسر و لئوناردو جیاچیونو به‌خاطر ارائه‌ی مثالی مشابه در کتابشان سپاسگزارم.
 Jonathan Lesser and Leonardo Giacchino, *Fundamentals of Energy Regulation* (Reston, VA: Public Utilities Reports Inc., 2013).
7. James Gleick, *The Information: A History, a Theory, a Flood* (New York: Vintage, 2011), 126, 170.
8. "Forms of Energy Basics," Energy Kids, EIA, www.eia.gov/kids/energy.php?page=about_forms_of_energy-basics.
۹. در سال ۲۰۱۷، تولید جهانی برق $۲۵/۵۰۰$ تراوات - ساعت بود که برابر با حدود ۷۰ تراوات - ساعت در روز یا $۲/۹$ تراوات - ساعت در ساعت است. حدود یک میلیارد خودرو در جهان وجود دارد و هر باتری خودرو توان نگهداری حدود هزار وات-ساعت دارد. بنابراین همه‌ی باتری‌های خودروهای جهان توانایی ذخیره‌ی حدود یک تریلیون وات-ساعت یا یک تراوات - ساعت انرژی دارند. این مقدار کمتر از سی دقیقه برق برای جهان فراهم خواهد کرد.
۱۰. در نظام بین‌المللی واحدهای اندازه‌گیری، واحدهایی که به‌جای نام افراد گذاشته می‌شود با حروف بزرگ است. بنابراین، وات به نمایندگی از جیمز وات نامیده شد، توجه دارید که با حرف بزرگ W است و ولت به نمایندگی از ولتا با حرف بزرگ V آمده است. کوتاه‌نوشت برای ساعت با حرف بزرگ نیست چون از نام فرد گرفته نشده است. برای ارجاع، هزار وات برابر با $۳۴/۱$ توان اسب است.

۱۱. داده‌ها از اداره اطلاعات انرژی، «جدول ۱-۲ خلاصه آمار برای امریکا، ۲۰۰۷ تا ۲۰۱۷»،
www.eia.gov/electricity/annual/html/epa_01_02.html,
 بنگرید به جدول ۴-۲ ب. در تابستان ۲۰۱۷، کل ظرفیت مقیاس برق نصب‌شده ۱/۰۸۴
 تراوات بود.

فصل ۲. نیروی دگرگون‌کننده برق

۱. آلکس اپستین، نویسنده کتاب دفاع اخلاقی از سوخت‌های فسیلی (نیویورک: نشر پرتفلیو، ۲۰۱۴) دفاع محکم و پایدار از نقش انرژی در شکوفایی بشر کرده است.
2. Wolfgang Schivelbusch, *Disenchanted Night: The Industrialization of Light in the Nineteenth Century* (Berkeley: University of California Press, 1995), 81-82.
3. Schivelbusch, *Disenchanted Night*, 45.
4. Schivelbusch, *Disenchanted Night*, 158.
5. Schivelbusch, *Disenchanted Night*, 35.
6. Wikipedia, s.v. "Great Chicago Fire," last modified May 10, 2019, 20:38, https://en.wikipedia.org/wiki/Great_Chicago_Fire.
7. Schivelbusch, *Disenchanted Night*, 52.
8. David E. Nye, *Electrifying America: Social Meanings of a New Technology* (Cambridge, MA: MIT Press, 1990), 5.
9. Phillip F. Schewe, *The Grid: A Journey Through the Heart of Our Electrified World* (Washington, DC: Joseph Henry Press, 2007), 38.
10. Maury Klein, *The Power Makers: Steam, Electricity, and the Men Who Invented Modern America* (New York: Bloomsbury, 2008), 171.
11. Klein, *The Power Makers*, 172.
12. Max Roser, "Light," *Our World in Data*, <https://ourworldindata.org/light>.
13. Department of Energy, "Energy Savings Estimates of Light Emitting Diodes in Niche Lighting Applications," October 2008, xiv, www.energy.gov/sites/prod/files/maprod/documents/Energy_Savings_Light_Emitting_Diodes_Niche_Lighting_Apps.pdf.

۱۴. آلبانی حدود ۷/۱ تراوات - ساعت برق و لتونی حدود ۶/۷ تراوات - ساعت برق در سال مصرف می‌کنند.
- “Country Comparison: Electricity—Consumption,” CIA World Factbook, www.cia.gov/library/publications/the-world-factbook/rankorder/2233rank.html.
15. BBC History, s.v. “James Watt (1736–1819),” www.bbc.co.uk/history/historic_figures/watt_james.shtml.
16. Charles R. Morris, *The Dawn of Innovation: The First American Industrial Revolution* (New York: PublicAffairs, 2012), 110.
17. Craig R. Roach, *Simply Electrifying: The Technology That Transformed the World, from Benjamin Franklin to Elon Musk* (Dallas: BenBella Books, 2017), 27.
۱۸. البته که همه انواع برق‌ها نظم بالایی ندارند. آذرخش و الکتریسته ساکن مثال‌های روشن از انرژی‌های الکتریکی نامنظم هستند.
19. Encyclopedia of Earth, s.v. “Energy Transitions,” by Arnulf Grubler, June 3, 2008, https://editors.eol.org/eoearth/wiki/Energy_transitions.
20. Vaclav Smil, “Power Density Primer,” May 8, 2010, <http://vaclavsmil.com/wp-content/uploads/docs/smil-article-power-density-primer.pdf>.
21. Vaclav Smil, *Power Density: A Key to Understanding Energy Sources and Uses* (Cambridge, MA: MIT Press, 2015), 86–87.
22. Smil, *Power Density*, 166.
23. Nye, *Electrifying America*, 228.
24. Smil, *Power Density*, 166.
25. “Ford Rouge Timeline,” The Henry Ford, www.thehenryford.org/visit/ford-rouge-factory-tour/history-and-timeline/timeline. See also, “Henry Ford River Rouge Plant,” Detroit: The History and Future of Motor City, <http://detroit1701.org/Ford%20Rouge%20Plant.html>.
26. Nye, *Electrifying America*, 225.
27. Eliot Spitzer, *Con Edison’s July 1999 Electric Service Outages: A Report to the People of the State of New York* (Albany, March 9, 2000), G-2, G-3.
28. See, Jayanth C. P. Koliyadu et al., “Optimization and Characterization of

High-Harmonic Generation for Probing Solid Density Plasmas,” *Photonics* 4, no. 2 (March 30, 2017), www.mdpi.com/2304-6732/4/2/25.

۲۹. کُرکوم و دیگران از چیزی که به تقویت نبض تیز شده (chirped pulse amplification) مشهور شده است استفاده می‌کنند که در آن با امتداد دادن انفجارهای کوتاه نور از شدت آن می‌کاهند. آن‌ها سپس همان نبض را تقویت و فشرده می‌کنند، که شدت آن را بسیار افزایش می‌دهد. جایزه نوبل سال ۲۰۱۸ فیزیک برای کار پیش‌تازانه انجام‌شده روی این نوع لیزر داده شد. یکی از دریافت‌کنندگان جایزه دونا استریکلند از کانادا بود، سومین زنی که جایزه نوبل دریافت کرد.

See, Emily Conover, “Dazzling Laser Feats Earn These Physicists a Nobel,” *Science News*, October 2, 2018, www.sciencenews.org/article/dazzling-laser-feats-earn-these-physicists-nobel.

30. Wm. A. Wulf, “Great Achievements and Grand Challenges,” *The Bridge* (Fall/Winter 2000): 5, www.nae.edu/File.aspx?id=7327.

31. Yilmaz Bayar and Hasan Alp Özel, “Electricity Consumption and Economic Growth in Emerging Economies,” *Journal of Knowledge Management, Economics and Information Technology* 4, no. 2 (April 2014).

32. Roger Andrews, “Electricity and the Wealth of Nations,” *Energy Matters* (blog), November 22, 2015, <http://euanmearns.com/electricity-and-the-wealth-of-nations/>.

33. Kashif Imran and Masood Mashkoo Siddiqui, “Energy Consumption and Economic Growth: A Case Study of Three SAARC Countries,” *European Journal of Social Sciences* 16, no. 2 (2010), www.scribd.com/document/39466448/Energy-Consumption-and-Economic-Growth.

34. Keith Bradsher, “China’s Unemployment Swells as Exports Falter,” *New York Times*, February 5, 2009, www.nytimes.com/2009/02/06/business/worldbusiness/06yuan.html.

تحلیلگرهای گلدمن ساکس خاطرنشان کرده‌اند که آن‌ها نیز از داده‌های برق به‌عنوان متغیر جانشین برای تولید در چین استفاده می‌کنند.

35. Xi Chen and William D. Nordhaus, “The Value of Luminosity Data as a

- Proxy for Economic Statistics” (working paper no. 16317, National Bureau of Economic Research, Cambridge, MA, August 2010), www.nber.org/papers/w16317.pdf.
36. J. Vernon Henderson, Adam Storeygard, and David N. Weil, “Measuring Economic Growth from Outer Space,” *American Economic Review* 102, no. 2 (April 2012), www.aeaweb.org/articles?id=10.1257/aer.102.2.994.
37. OECD/IEA, “Electric Power Consumption (kWh per capita),” World Bank, http://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC?year_high_desc=true.
38. Cited by Marian L. Tupy in *The False Promise of Gleneagles: Misguided Priorities at the Heart of the New Push for African Development* (Washington, DC: Cato Institute, 2009), <https://object.cato.org/sites/cato.org/files/pubs/pdf/dpa9.pdf>.
39. Credit here to Edward Glaeser and his book *Triumph of the City: How Our Greatest Invention Makes Us Richer, Smarter, Greener, Healthier, and Happier* (New York: Penguin, 2011).

فصل ۳. شهر عمودی

1. Quoted in Richard Rhodes, *Energy: A Human History* (New York: Simon & Schuster, 2017).
2. “Brooklyn Bridge,” History.com, last updated August 21, 2018, www.history.com/topics/brooklyn-bridge.
3. “Population History of New York from 1790–1990,” Boston University Physics, <http://physics.bu.edu/~redner/projects/population/cities/newyork.html>.
4. David W. Dunlap, “Consumed in Fire, Cloaked in Ice, Equitable’s Headquarters Fell 100 Years Ago,” *City Room* (blog), *New York Times*, January 8, 2012, <https://cityroom.blogs.nytimes.com/2012/01/08/consumed-in-fire-cloaked-in-ice-equitable-headquarters-fell-100-years-ago/>.

۵. برای نقشه‌ای از نخستین شبکه برق ادیسون بنگرید به؛

Kelsey Campbell-Dollaghan, "The Forgotten Story of NYC's First Power Grid," *Gizmodo*, January 26, 2015, <https://gizmodo.com/the-forgotten-story-of-nycs-first-power-grid-1681857054>.

برای نقشه پیاده‌روی بنگرید به نقشه‌های گوگل

<https://bit.ly/2VkeewT>.

۶. مبدل در عصر برق، مانند ریزپردازنده در عصر اطلاعات است، وستینگ‌هاوس در سال ۱۸۸۵ در یک مجله مهندسی انگلیسی مقاله‌ای دربارهٔ وسیله‌ای خواند که ولتاژ را در سامانه‌ای با جریان متغیر، افزایش یا کاهش می‌داد. وستینگ‌هاوس مردی که دستکاری شخصی و تیزهوشی کسب و کاری افسانه‌ای داشت، اهمیت چیزی که بعدها «موتور برق ثانویه» نامیده شد حس کرد. او به سرعت با اعزام فرستاده‌ای به اروپا تصمیم گرفت حقوق معنوی مبدل را به دست آورد. وستینگ‌هاوس متوجه شد با استفاده از مبدل‌ها می‌توان ولتاژ را در خطوط انتقال جریان متناوب افزایش داد و در نتیجه برق بیشتری به مناطق دور دست ارسال کرد. در سال ۱۸۹۶، وستینگ‌هاوس نخستین سامانه برق فشار قوی را ساخت که از جریان متناوب استفاده می‌کرد. او با استفاده از ۱۱ هزار ولت خطوط انتقال، ایستگاه برق آبی در آبشار نیاگارا را به شهر بوفالو در ۳۲ کیلومتر آن طرف‌تر متصل کرد. پس از این که وستینگ‌هاوس کارآیی طراحی برق متناوب آبشار نیاگارا را ثابت کرد، موتورهای برق سراسر جهان شروع به کپی کردن طراحی فشارقوی وستینگ‌هاوس کردند. در سال ۱۹۰۰، تولیدکنندگان، برق را در خطوط شصت هزار ولتی انتقال می‌دادند. در سال ۱۹۱۲، آن ولتاژ بیش از دو برابر و به ۱۵۰ کیلوولت رسید. در سال ۱۹۳۰، بیش از ۲۴۰ کیلوولت را مدیریت می‌کردند. امروز، شرکت‌های برق معمولاً از خطوط فشارقوی‌ای بهره می‌برند که ۳۶۰ و ۷۲۰ کیلوولت را مدیریت می‌کنند. برای اطلاعات بیشتر بنگرید به:

Jill Jonnes, *Empires of Light: Edison, Tesla, Westinghouse, and the Race to Electrify the World* (New York: Random House, 2003), 123–125. See also, Matthew H. Brown and Richard P. Sedano, *Electricity Transmission: A Primer* (Washington, DC: National Council on Electricity Policy, 2004), 2, www.energy.gov/sites/prod/files/oeprod/DocumentsandMedia/primer.pdf.

7. Frederick Dalzell, *Engineering Invention: Frank J. Sprague and the U.S. Electrical Industry* (Cambridge, MA: MIT Press, 2009).

8. Dalzell, *Engineering Invention*, 768.

9. Paul Israel, *Edison: A Life of Invention* (New York: John Wiley & Sons, 1998), 223.
10. Joseph J. Cunningham, *New York Power* (Self-published, CreateSpace, 2013), 19.
11. Frank Rowsome Jr., *The Birth of Electric Traction: The Extraordinary Life and Times of Inventor Frank Julian Sprague* (Self-published, CreateSpace, 2013).
12. Cunningham, *New York Power*, 20.
13. Robert Bradley Jr., "Horsepower Sure Beats Horses!" *MasterResource* (blog), September 29, 2009, <http://masterresource.org/?p=5016>.
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براساس گزارش ۲۰۱۹ صلح سبز تا پایان ۲۰۱۸، آمازون فقط ۱۶۸۶ مگاوات ظرفیت در مرکز دادهٔ ویرجینیا داشت. گزارش ۲۰۱۷ نشان می‌دهد که این شرکت در سال ۲۰۱۶ به میزان ۵۴۲ مگاوات ظرفیت در سایر مراکز دادهٔ داخل امریکا و ۸۸۶ مگاوات ظرفیت تولید در سایر کشورها داشته است. با توجه به رشد سریع AWS طی چند سال پیش، تخمین می‌زنم ظرفیت داخلی مراکز داده خارج از ویرجینیا در فاصلهٔ سال ۲۰۱۶ تا انتهای ۲۰۱۸ دو برابر شده باشد.

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۱. خانه سه خوابه وی ماهانه حدود هفت هزار کیلووات-ساعت برق مصرف می‌کرد. هر خانه در کلرادو به‌طور متوسط کمتر از هفتصد کیلووات-ساعت در ماه برق مصرف می‌کند. بنگرید به؛

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کاربرگ‌های بحث‌شده در گزارش ۲۰۱۵ با جزئیات هر ایالت نیز به صورت آنلاین در استنفورد منتشر شد. دربارهٔ این کاربرگ‌ها به بخش «جزئیات میانی بر حسب ایالت، بنگرید به؛

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شایان توجه است که سه ماه پس از انتشار مقالهٔ کلاک، جیکبسون از کلاک در دادگاه فدرال شکایت کرد (اما هیچ‌یک از نویسنده‌های همکار وی شکایتی نکردند) و علیه او ده میلیون دلار بابت افترا ادعای خسارت کرد. جیکبسون از فرهنگستان ملی علوم نیز شکایت کرد. جیکبسون شکایت کرد که مقالهٔ کلاک باعث بدنامی او و همکارانش شده است به طوری که آن‌ها «پژوهشگران بیچاره، شلخته، بی‌کفایت و بی‌خبر به نظر برسند.» بنگرید به؛

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مقاله حد وسط چگالی نیروی انرژی بادی را ۰/۵ وات بر متر مربع و حد وسط خورشیدی را ۵/۴ وات بر متر مربع ارزیابی کرده است.

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فصل ۱۸. این زمین، زمین من است

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- توجه دارید این بررسی، مشابه کار سالت، بر این واقعیت تأکید می‌کند که «وجود تفاوت بین افراد در زمینهٔ درجهٔ حساسیت شنوایی باعث می‌شود برخی آدم‌ها "ناشنیدنی‌ها" را تشخیص دهند.» آن‌ها این‌گونه ادامه می‌دهند: «واکنش‌های قشر شنوایی و نوسان صدای حلزونی که در معرض مادون‌صوت‌ها قرار گرفته بودند مشاهده شد، در عین حال که گروه مورد آزمایش آهنگ صدا را درک نمی‌کرد. این بررسی‌ها شواهد قوی به نفع اثر مادون‌صوت بر واکنش‌های شنوایی مرکزی و محیطی انسان ارائه می‌دهد. به عبارت دیگر این که صدایی نمی‌شنویم به این معنی نیست که بدن ما به آن واکنش نشان نمی‌دهد.
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۹. جایگیری، یا چگالی ظرفیت، انرژی باد، سه وات بر متر مربع است. بنابراین چهار میلیارد وات تقسیم بر سه وات بر متر مربع = ۱/۳۳۳ میلیارد متر مربع یا ۱۳۳۳ کیلومتر مربع می‌شود.
۱۰. توجه دارید که تولید پیش‌بینی‌شده پروژه بادی فراساحلی ۴/۱ گیگاوات-ساعت در

مگاوات ظرفیت نصب‌شده، به میزان چشمگیری بالاتر از تولید ثبت‌شده پروژه‌های بادی فراساحلی است. برای مثال در سال ۲۰۱۷، تگزاس ظرفیت بادی نصب‌شده ۲۲/۶۳۷ مگاواتی داشت که ۶۷/۰۶۱ گیگاوات - ساعت برق تولید کرد. بنابراین در یکی از بهترین ایالت‌های امریکا برای انرژی باد، یک مگاوات ظرفیت بادی حدود ۳ گیگاوات - ساعت برق در سال تولید می‌کند. برای دیدن ظرفیت انرژی بادی ۲۰۱۷ در تگزاس بنگرید به: "U.S. Installed and Potential Wind Power Capacity and Generation," WindExchange, <https://windexchange.energy.gov/maps-data/321>. For 2017 wind output in Texas, see "Electricity Data Browser," EIA, <https://bit.ly/2EwmlRU>.

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