

## **A Collection of Links regarding US Renewable Energy Potential**

Great blog on Virginia issues by Ivy Main: <https://powerforthepeopleva.com>

General SouthEast energy blog: <http://southeastenergynews.com>

### **Potential for US Grid to be powered by renewables and storage**

NREL: renewables can supply 80% of US needs by 2050 with today's technology:

[http://www.nrel.gov/analysis/re\\_futures/](http://www.nrel.gov/analysis/re_futures/)

<http://www.nrel.gov/docs/fy13osti/52409-ES.pdf>

<http://ieeexplore.ieee.org/xpl/articleDetails.jsp?reload=true&arnumber=6690152>

Federal government plan for 86 GW of off-shore wind by 2050:

<http://www.climatecentral.org/news/obama-administration-vision-for-offshore-wind-20689>

<http://energy.gov/sites/prod/files/2016/09/f33/National-Offshore-Wind-Strategy-report-09082016.pdf>

NOAA, CIRES study: "Our research shows a transition to a reliable, low-carbon, electrical generation and transmission system can be accomplished with commercially available technology and within 15 years."

<http://www.noaanews.noaa.gov/stories2016/012516-rapid-affordable-energy-transformation-possible.html>

University of Colorado: US grid can be powered by solar & wind by 2030:

<https://www.sciencedaily.com/releases/2016/01/160125114231.htm>,

<http://www.nature.com/nclimate/journal/v6/n5/full/nclimate2921.html>

Wind, solar and storage can power US grid 99.9% of the time, from Journal of Power Sources:

<http://www.sciencedirect.com/science/article/pii/S0378775312014759>

Many examples of current state and utility successes, including integrating wind and solar:

[http://www.ucsus.org/sites/default/files/legacy/assets/documents/clean\\_energy/Ramping-Up-Renewables-Energy-You-Can-Count-On.pdf](http://www.ucsus.org/sites/default/files/legacy/assets/documents/clean_energy/Ramping-Up-Renewables-Energy-You-Can-Count-On.pdf)

DOE: Integrating 54 GW of wind into US grid:

<http://energy.gov/eere/downloads/national-offshore-wind-energy-grid-interconnection-study-nowegis>

80% renewables by 2050, with detailed timeline graphs of how to balance loads:

<http://cleantechnica.com/2015/12/16/how-the-grid-works-why-renewables-can-dominate/>

US now has more wind power than nuclear, renewables will be #1 power source by 2040:

<http://fusion.net/story/271445/global-wind-nuclear-power/>

How Hawaii is balancing load with renewables:

<http://www.hawaiibusiness.com/balancing-hawaiis-energy-supply-and-demand/>

Methods for using solar and wind to meet US demand, from NREL:

<http://www.nrel.gov/docs/fy15osti/63038.pdf>

Low Carbon Economy by Goldman Sachs: solar and wind power will add more power globally than shale:

<http://reneweconomy.com.au/2015/67742>

Cost of renewables keeps going down – solar to be 60% cheaper by 2025, off-shore wind will go down by 35%:

<http://www.bloomberg.com/news/articles/2016-06-15/cost-of-clean-energy-to-keep-nosediving-into-next-decade>

Scientific American, Intermittent nature of renewables can be managed by combining them:

<http://blogs.scientificamerican.com/plugged-in/renewable-energy-intermittency-explained-challenges-solutions-and-opportunities/>

Utility getting “ahead of the game”

<http://www.renewableenergyworld.com/articles/2016/05/massachusetts-utility-seeks-to-stay-ahead-of-the-game-with-solar-grid-penetration.html>

Investment in renewables:

[RE World article on investment](#)

World Bank: “Very high levels of variable renewable energy can be accommodated both technically and at low cost.”

<http://thinkprogress.org/climate/2016/02/01/3743082/renewables-revolution/>

Storing The Sun’s Energy Just Got A Whole Lot Cheaper

With prices dropping rapidly for both renewables and battery storage, the economics of decarbonizing the grid are changing faster than most policymakers, journalists, and others realize, and revenue stacking makes storage a rapid financial success:

<http://thinkprogress.org/climate/2016/05/18/3778623/new-economics-solar-plus-battery-storage/>

By 2030, Renewables Will Be The World’s Primary Power Source

<http://thinkprogress.org/climate/2016/01/27/3712181/renewables-surpass-coal-2030/>

[http://www.worldenergyoutlook.org/pressmedia/recentpresentations/151110\\_WEO2015\\_presentation.pdf](http://www.worldenergyoutlook.org/pressmedia/recentpresentations/151110_WEO2015_presentation.pdf)

<http://thinkprogress.org/climate/2016/01/29/3743517/congress-natural-gas-renewables/>

The ConEd program represents one of the most ambitious U.S. efforts yet to turn lots of distributed solar installations into a flexible source of grid power that can replace electricity from the fossil-fuel plants that are typically used to supplement intermittent renewable energy.

<https://www.technologyreview.com/s/601695/virtual-power-plants-get-around-solar-powers-intermittency-problem/>

In the first three months of 2016, the U.S. grid added 18 MW of new natural gas generating capacity. It added a whopping 1,291 MW of new renewables. So the U.S. electric grid added more than 70 times as much renewable energy capacity as natural gas capacity from January to March.

<http://thinkprogress.org/climate/2016/05/16/3778542/grid-70-times-renewables-natural-gas/>

A national system of electricity transmission could cut power-plant emissions by 80%:

<http://www.theatlantic.com/magazine/archive/2016/06/the-energy-interstate/480756/>

Exploding 6 myths about renewables:

<http://www.greenpeace.org/international/en/campaigns/climate-change/energyrevolution/renewable-energy-myths/>

Relevant conference: CERES conference 2016 -- Business Not As Usual: Sustainability In An Age Of Disruption, with sessions like *Plug In And Power Ahead: How The Utility And Auto Industries Can Help Each Other Achieve A Clean Energy Future*: <http://www.ceresconference.org>

US recent progress:

Since 2008, electricity generation from solar has increased more than thirty-fold and electricity generation from wind has more than tripled.

US put the first solar plant on public lands, the first steel was put in the water for US offshore wind, and we are on a path to have 20 GW of renewables permitted.

<https://www.whitehouse.gov/the-record/climate>

Why Smart Utilities are investing in Distributed Generation

<http://ensia.com/voices/smart-utilities-embracing-distributed-electricity/>

The Falling Cost of Solar in 7 charts:

Solar growth in US from 0 in 2007 to 29GW in 2016 to 100GW estimated in 2020

<http://www.vox.com/2016/8/24/12620920/us-solar-power-costs-falling>

Benefits of State Renewable Energy Standards (Renewable Portfolio Standards - RPS):

A new report from the Department of Energy's (DOE's) Lawrence Berkeley National Laboratory (LBNL) and National Renewable Energy Laboratory (NREL) finds that state renewable portfolio standard (RPS) policies reduced greenhouse gas emissions and air pollution, while also reducing water use, creating renewable energy jobs and suppressing wholesale electricity and natural gas prices. The greenhouse gas and air pollution benefits alone saved the United States society \$7.4 billion in 2013. Although not directly comparable, a previous report by the same lab team found average annual costs of RPS policies of only \$1 billion: in other words, the benefits of these policies have vastly outweighed their costs.

<http://energy.gov/eere/articles/new-study-renewable-energy-state-renewable-portfolio-standards-yield-sizable-benefits>

Regarding the argument that solar takes too much land area:

Most analyses show that the US could fulfill all the nation's energy use needs with solar using less than 0.6% of US land area; and, this can include building and home rooftop area and not just vacant land. That would be a total of 14 million acres. By contrast, coal has disturbed 9 million acres in the US, and produces less than 40% of US energy; i.e. solar has a smaller land footprint per unit of energy than coal. If we apply this just to Virginia, 0.6% of the land would be 160,000 acres. Half of this could be installed on suitable rooftops. That leaves 80,000 acres to place at airports and other suitable land areas – a reasonable amount. And this does not consider the fact that solar will get more efficient, and some of the renewable will be provided by wind, so that the full 160,000 acres in Virginia will not be needed.

<http://www.nrel.gov/docs/fy13osti/56290.pdf>

<http://www.renewableenergyworld.com/articles/2013/08/calculating-solar-energys-land-use-footprint.html>

<http://rameznaam.com/2015/04/08/how-much-land-would-it-take-to-power-the-us-via-solar/>

<http://grist.org/article/2010-11-17-which-has-bigger-footprint-coal-plant-or-solar-farm/>

Solar costs have fallen >70% in 10 years, 4 GW installed in US in 1<sup>st</sup> half of 2016, 32 GW now installed:

<http://www.seia.org/research-resources/solar-industry-data>

Solar is 64% of new electrical capacity in Q1 2016:

<http://www.greentechmedia.com/articles/read/solar-accounted-for-64-of-new-electric-generating-capacity-in-the-us-in-q1>

Advanced solar inverter technology improves integration to grid:

<http://midwestenergynews.com/2016/08/09/how-an-obscure-piece-of-technology-will-help-put-more-solar-on-the-grid/>

<https://energy.gov/eere/success-stories/articles/eere-success-story-epri-lays-foundation-smart-inverter-technology>

80% of US homes have good solar potential:

<https://www.engadget.com/2017/03/15/google-4-out-of-5-us-homes-have-solar-power-potential/>

## Minnesota cities learn from buying community solar together

<http://midwestenergynews.com/2017/04/03/minnesota-cities-learn-from-buying-community-solar-together/>

### Investor's viewpoint

<https://www.linkedin.com/pulse/heres-why-i-think-renewable-energy-finally-living-up-hype-holmes>

Xcel says company-wide carbon emissions down 30% since 2005, plans to cut 45% by 2021

<http://www.bizjournals.com/denver/news/2017/05/30/xcel-says-company-wide-carbon-emissions-down.html>

U.S. Renewable Energy Jobs Employ 800,000+ People and Rising (solar up 82% over 3 years, wind up 100%)

<https://insideclimatenews.org/news/26052017/infographic-renewable-energy-jobs-worldwide-solar-wind-trump>

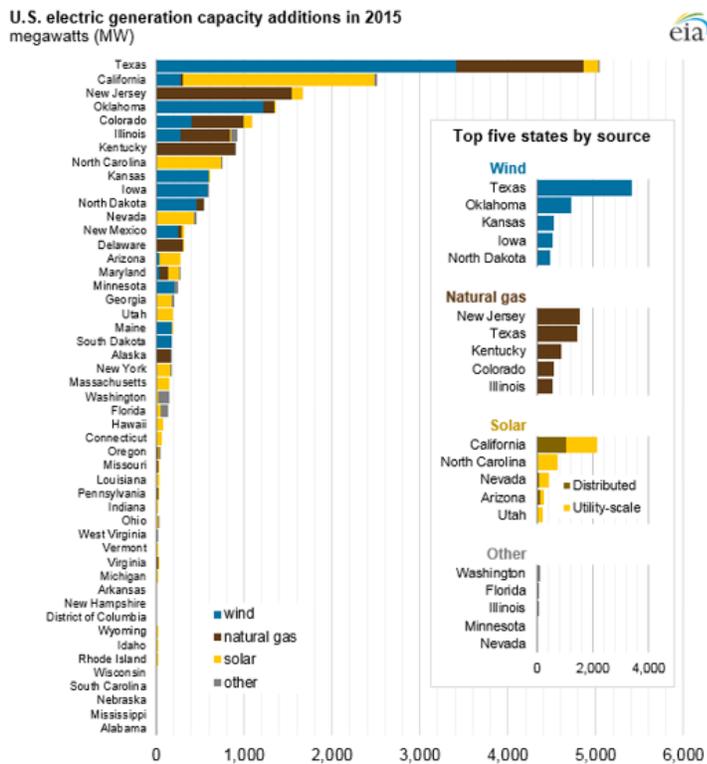
## Instances of solar installed without natural gas

(The reason for these two sections is that Tom Farrell of Dominion made a statement at the 2016 shareholder meeting that renewables could not be installed except “hand-in-hand” with natural gas. Of course, the preceding section also goes to show that is false).

California has installed 3-5 GWh of solar energy every year since 2012, with a net decrease in natural gas generation:

[http://energyalmanac.ca.gov/electricity/electric\\_generation\\_capacity.html](http://energyalmanac.ca.gov/electricity/electric_generation_capacity.html)

See below image from EIA, <http://www.eia.gov/todayinenergy/detail.cfm?id=25492>; obviously many states have installed solar (and wind) without gas.



## Instances of wind installed without natural gas:

MidAmerican:

MidAmerican has integrated ~40% wind without natural gas -- has built over 3 GW of wind since 2005 and has 2 GW more of wind planned in next 2-3 years, and hasn't built a gas plant since 2003.

<https://midamericanenergy.com/our-renewable-energy-vision.aspx>

“In 2004, 70% of our generation capacity came from coal and nothing came from wind. At year-end 2015, 41% of our generation capacity came from wind and 37% came from coal.

In April 2016, we announced our 100% renewable vision; we want to provide 100% renewable energy for our customers.

When the Wind XI project is complete, our annual renewable energy generation is expected to reach 85% of our customers' annual retail usage.”

## Local Wind

Wind resources in VA and WV

[http://apps2.eere.energy.gov/wind/windexchange/wind\\_resource\\_maps.asp?stateab=vw](http://apps2.eere.energy.gov/wind/windexchange/wind_resource_maps.asp?stateab=vw)

[http://apps2.eere.energy.gov/wind/windexchange/wind\\_resource\\_maps.asp?stateab=va](http://apps2.eere.energy.gov/wind/windexchange/wind_resource_maps.asp?stateab=va)

George Hagerman (Virginia Tech Advanced Research Institute) has shown that costs for VOWTAP are in-line with costs for the first US off-shore wind farm, Brock Island.

For comparison with VOWTAP sans cable, Block Island unit capital cost calculation:

Block Island Wind Farm (BIWF) financing = \$290 million debt + \$70 million equity = \$360 million for five 6-MW turbines:

<http://dwwind.com/wp-content/uploads/2015/04/3-2-Bloomberg-Business.pdf>

This yields a unit capital cost of \$12 million per megawatt, which is within the range estimated for VOWTAP sans cable: \$10.8 to \$14.7 million per megawatt.

Global median cost is \$5M/MW (for Europe, where they have been doing this much longer).

The above references the NREL 2014-2015 Offshore Wind Technologies Market Report, which can be downloaded at

[www.nrel.gov/docs/fy15osti/64283.pdf](http://www.nrel.gov/docs/fy15osti/64283.pdf) for 114-page technical report, dated Sep 2015

[www.nrel.gov/docs/fy16osti/65435.pdf](http://www.nrel.gov/docs/fy16osti/65435.pdf) for 35-slide briefing, dated Nov 2015

Wind and jobs: The wind industry [tops 100,000 workers](#) in 2016, while the [demand for wind turbine technicians](#) is growing faster than any other occupation in the U.S., according to the Bureau of Labor Statistics.

## Virginia Renewables Status

Virginia ranks 41<sup>st</sup> in the 50 states...

<http://www.ucsusa.org/clean-energy/increase-renewable-energy/momentum#.WPlri11-LqV>

<http://www.ucsusa.org/sites/default/files/attach/2017/04/Clean-Energy-Momentum-Technical-Document.pdf>

Virginia lags far behind neighboring states in terms of renewables installed. Bob Blue, in a speech at the Virginia Chamber of Commerce conference on Energy, Sustainability & Resiliency (May 10, 2016), characterized Dominion’s slow approach to renewables as a Kentucky Derby start where “the first horse out of the gate doesn’t always win.” The problem is that Virginia is so far behind in renewables as this point, that it is questionable whether they will ever catch up. Looking at EIA data on renewable generation for Virginia and its neighboring states from recent years, Virginia does not seem to be making any progress in closing the gap. From 2014 data, Virginia has 2.6% as much renewable generation as its neighbors, despite having (on average) 38% higher population.

EIA data 2010 <http://www.eia.gov/renewable/state/pdf/srp2010.pdf>

<b>MW</b>	<b>Maryland</b>	<b>NC</b>	<b>W Virginia</b>	<b>Tennessee</b>	<b>Virginia</b>
Solar	1	35	0	0	0
Wind	70	0	431	29	0
<b>Total</b>	<b>71</b>	<b>35</b>	<b>431</b>	<b>29</b>	<b>0</b>

Avg neighboring states **142**

EIA data 2013 <http://www.eia.gov/electricity/data/state/>

<b>MW</b>	<b>Maryland</b>	<b>NC</b>	<b>W Virginia</b>	<b>Tennessee</b>	<b>Virginia</b>
Solar	62	336		16	0
Wind	120	0	583	29	0
<b>Total</b>	<b>182</b>	<b>336</b>	<b>583</b>	<b>45</b>	<b>0</b>

Avg neighboring states **287**

EIA data 2014

<b>MW</b>	<b>Maryland</b>	<b>NC</b>	<b>W Virginia</b>	<b>Tennessee</b>	<b>Virginia</b>
Solar	242	1011	3	119	14
Wind	160	0	583	29	0
<b>Total</b>	<b>402</b>	<b>1011</b>	<b>586</b>	<b>148</b>	<b>14</b>

Avg neighboring states **537**

NREL: Rooftop solar can provide 32% of Virginia electricity needs, and 40% of VA roofs are suitable for solar:

<http://www.nrel.gov/docs/fy16osti/65298.pdf>

Twice as many Virginians now work in renewables than coal:

<https://powerforthepeopleva.com/2017/02/10/while-u-s-leaders-were-worrying-about-coal-jobs-clean-energy-snatched-the-lead-even-virginia-now-has-more-people-working-in-solar-than-coal/>

Virginia governor announces PACE program for clean energy

<https://governor.virginia.gov/newsroom/newsarticle?articleId=8236>

For minorities and the poor, “cheap” energy comes at a high cost

<https://powerforthepeopleva.com/2017/02/27/for-minorities-and-the-poor-cheap-energy-comes-at-a-high-cost/>

Potential 50,000 Rooftop Solar Jobs in Virginia, and Virginia could make 32% of electricity from solar. Currently Virginia has 238 MW of solar while NC has 3012 MW.

<https://powerforthepeopleva.com/2017/03/02/potential-50000-rooftop-solar-jobs-in-virginia-for-ten-years/>

Town of Front Royal installs 3 MW solar field

<http://www.nvdaily.com/news/2017/03/towns-solar-power-field-nears-completion/>

A new study has found that Virginia's solar job market grew 65% in 2016. Nationwide, jobs in the solar industry jumped up to 25%.

<http://www.whsv.com/content/news/McAuliffe-praises-solar-job-grow-in-Virginia-417965423.html>

Virginia schools going solar:

<https://powerforthepeopleva.com/2017/04/24/arlington-creates-legal-authority-for-solar-on-schools-power-purchase-agreements-plans-october-rfp/>

## Legislation

Oregon law requires 50% renewable by 2040, phase out coal by 2030.

<http://www.eia.gov/todayinenergy/detail.cfm?id=25932#>

## Renewables in Europe:

### Wind

<http://www.ewea.org/statistics/>

As of 2015, 142 GW of installed wind energy capacity in the EU: approximately 131 GW onshore and 11 GW offshore. None are associated with gas facilities.

Denmark meets electric needs with wind, with no natural gas:

[https://en.wikipedia.org/wiki/Energy\\_in\\_Denmark#Electricity](https://en.wikipedia.org/wiki/Energy_in_Denmark#Electricity)

### Offshore Wind in Europe:

3 GW of new offshore wind power capacity was connected to the grid during 2015 in Europe, a 108.3% increase over 2014 and the biggest yearly addition to capacity to date.

419 new turbines were erected in 2015. Seven turbines were decommissioned in the UK and Sweden, resulting in a net addition of 412 turbines.

53 of these turbines equivalent to 277 MW are awaiting grid connection.

14 projects were completed in 2015. Work is on-going on six projects in Germany, the Netherlands and the UK.

### Solar in Europe

70 GW solar PV installed in Europe as of 2012. Almost none associated with gas plants.

2.3 GW concentrated solar power in Europe (allows storage and use over 24 hours).

31 GW solar thermal in Europe.

## Energy Efficiency

In California, decades ago, the state and utilities worked together, and set up incentives for the utilities to promote energy efficiency (so that the utility would make more money if it sold less electricity). Despite a soaring population, and a huge increase in gadgets that use electricity, California electricity use has been flat for decades because of these incentives.

In Massachusetts, one program is Mass Save, where when you buy or rent a house the utility will come out and do an energy audit for free, and seal up the worst leaks, for free, and pay for 75% of upgrading insulation (<http://www.masssave.com>).

This kind of thing is what Virginia needs – Dominion has always had an inherent conflict of interest because if they really promote efficiency, then they sell less electricity and make less money. But if they worked with the state to set up incentives for energy efficiency, then the profit motive wouldn't conflict with making, using and selling less electricity. If Dominion were to show less projected increase in demand in their IRP, it would be easier to show that renewables plus storage can meet future demand levels.

Maryland residents use 38% less electricity per capita than Virginia residents – if Dominion could implement measures in VA to make up that gap, it would go far toward flattening future demand.

## Climate Silence

Some of the reasons people don't talk about climate change:

<https://www.washingtonpost.com/news/energy-environment/wp/2016/05/12/the-vicious-cycle-that-makes-people-afraid-to-talk-about-climate-change/>

Another statement made by Mr. Farrell at the 2016 Dominion shareholder meeting that I had an issue with was, "Solar panels don't produce power when it's cloudy." I really hope this is not something Mr. Farrell believes, because it's woefully ignorant. At our home, we make more power on a cloudy morning than on a clear one, because we get more diffuse sunlight on the panels, at an hour when there is no direct sun on the array. Even in the afternoon, clouds do not cut our production by that much, and it's certainly not true that the panels "don't produce power" when it's cloudy.

## Communities that have committed to 100% renewable energy

<http://www.go100percent.org/cms/>

**So far:** 8 Countries, 55 Cities, 61 Regions/States, 9 Utilities, 21 Institutions, totaling more than **54.9 million people** (and counting...) who have shifted or are committed to shifting within the next few decades to **100% renewable energy** in at least one sector (e.g. electricity, transportation, heating/cooling).

<http://www.go100re.net>

Copenhagen carbon neutral by 2025

<https://stateofgreen.com/en/profiles/city-of-copenhagen>

Mar Vista 100% renewable by 2018

[http://www.go100percent.org/cms/index.php?id=77&tx\\_ttnews%5Btt\\_news%5D=88&cHash=f7e076ae8422e9ede42cb8a53dae7895](http://www.go100percent.org/cms/index.php?id=77&tx_ttnews%5Btt_news%5D=88&cHash=f7e076ae8422e9ede42cb8a53dae7895)

Nassau NY 100% renewable by 2020

<http://ecowatch.com/2015/12/15/nassau-off-grid-renewables/>

Burlington VT became the [first American city to run on 100 percent clean energy](#) in early 2015

Columbia, Maryland: In September 2015, Columbia announced it would offset 100 percent of its energy use from renewable sources and signed a [20-year power purchase agreement](#) with SunEdison.

Sierra Club's *America's Ready for 100* program

<http://www.sierraclub.org/michael-brune/2016/01/americas-ready-for-100>

On the heels of the Paris negotiations, San Diego announced that it is going all-in on clean energy, becoming the largest U.S. city to commit to 100 percent clean energy

[http://www.nytimes.com/2015/12/16/science/san-diego-vows-to-move-entirely-to-renewable-energy-in-20-years.html?\\_r=0](http://www.nytimes.com/2015/12/16/science/san-diego-vows-to-move-entirely-to-renewable-energy-in-20-years.html?_r=0)

Ninety-One Illinois Communities Powered by 100% Green Electricity

<http://www.worldwildlife.org/press-releases/ninety-one-illinois-communities-powered-by-100-green-electricity>

<http://www.environmentillinois.org/programs/ile/100-renewable-energy>

Georgetown, Texas: 100% solar and wind by 2017

<http://www.popsoci.com/soon-texas-town-will-run-100-percent-renewable-energy>

Vancouver, British Columbia, Canada, voted in March to go 100 percent renewable by 2030, and not just for electricity but for heating, cooling, and maybe transportation as well.

<http://cleantechnica.com/2015/04/12/city-vancouver-votes-go-100-renewables/>

Two German states already at 100% renewable

<http://cleantechnica.com/2016/04/28/two-german-states-already-hit-100-renewable-electricity/>

Hawaii 100% renewable by 2045

<http://www.hawaiicleanenergyinitiative.org>

General Motors says it will power all of its global operations using 100 percent renewable energy by 2050, which will include 350 facilities in 59 countries:

<http://www.detroitnews.com/story/business/autos/general-motors/2016/09/14/gm-pledges-renewable-energy-power/90369186/>

NY State 50% renewable by 2030

<https://www.governor.ny.gov/news/governor-cuomo-announces-establishment-clean-energy-standard-mandates-50-percent-renewables>

Frustrated by high electric bills and frequent shutoffs, one of Colorado's poorest cities passes a resolution to generate 100 percent of its power from renewables by 2035:

<https://thinkprogress.org/high-electricity-bills-prompted-this-colorado-city-to-commit-to-going-100-renewable-78c282f61beb#.x9i4ifjau>

The Atlanta city council approves a measure to power the city [entirely by renewable energy](#) by 2035.

CEO of Detroit-based DTE Energy, which plans to cut carbon emissions 80 percent and phase out coal use by 2050, says climate change is "the [policy issue of our era.](#)"

In rural Colleton County, Cottageville aims to be South Carolina's first fully renewable-powered town

[http://www.postandcourier.com/business/in-rural-colleton-county-cottageville-aims-to-be-south-carolina/article\\_1c90bf96-3cdc-11e7-8dd5-c345784d18c6.html](http://www.postandcourier.com/business/in-rural-colleton-county-cottageville-aims-to-be-south-carolina/article_1c90bf96-3cdc-11e7-8dd5-c345784d18c6.html)