

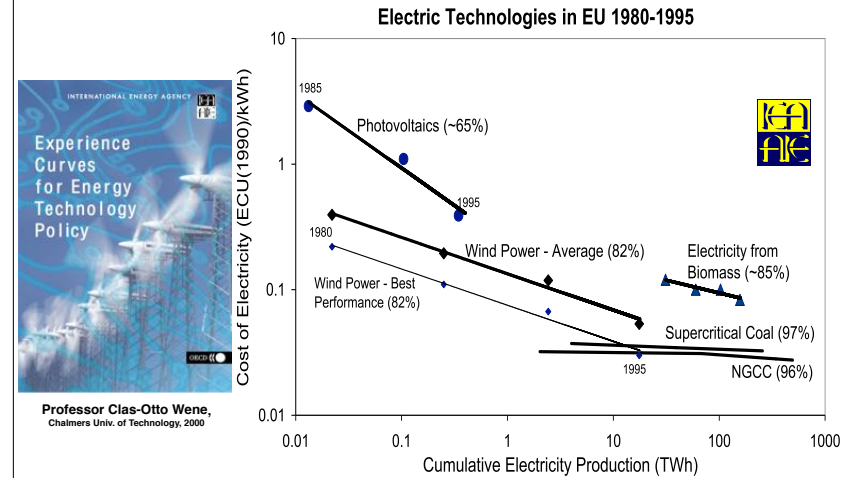
The Development of Renewables

Collège de France 2015-10-30

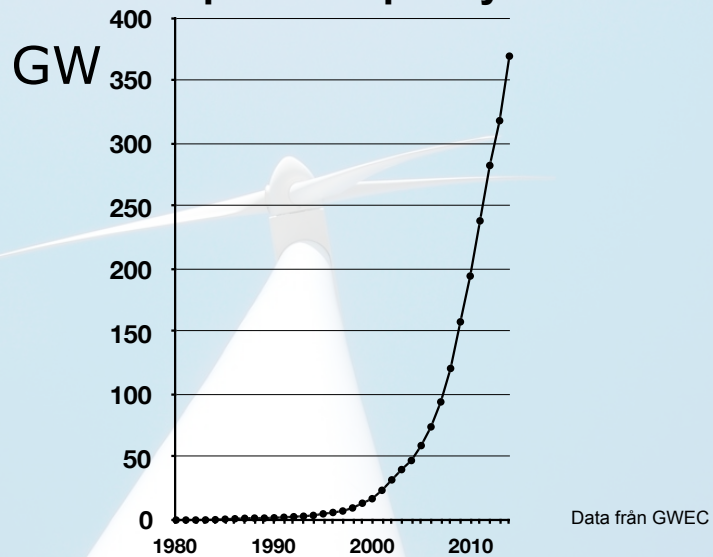
Tomas Kåberger

Professor of Industrial Energy Policy at Chalmers University of Technology
 visiting fellow/academy/professor at IAS TU München/IIIEE Lund Univ. / Zhejiang University
 Executive board chair Japan Renewable Energy Foundation

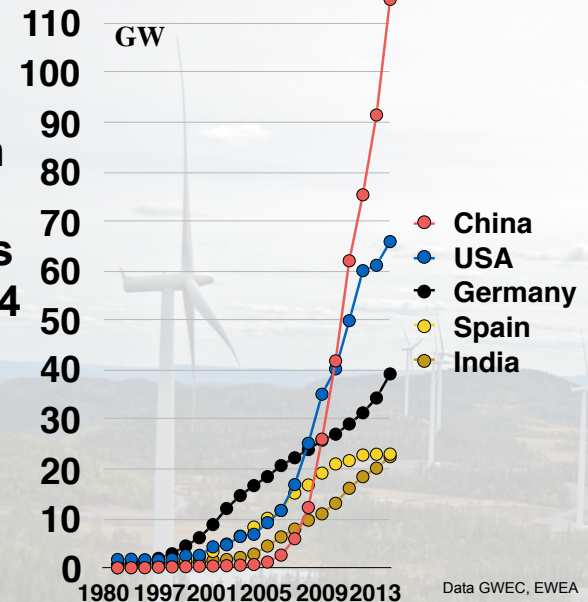
Industrial learning by experience



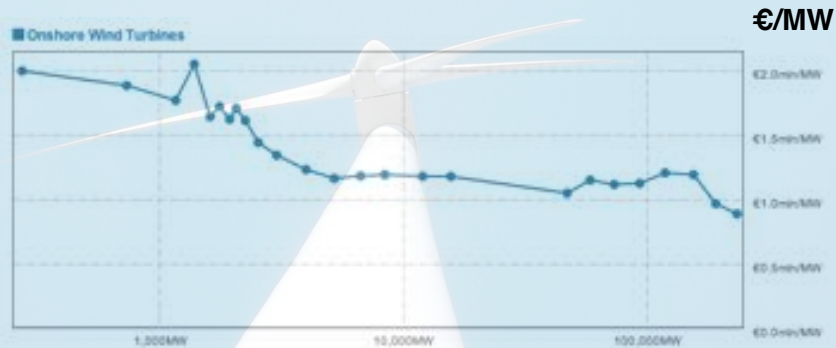
Global Wind power capacity 1980-2014



Wind power in leading countries 1980-2014



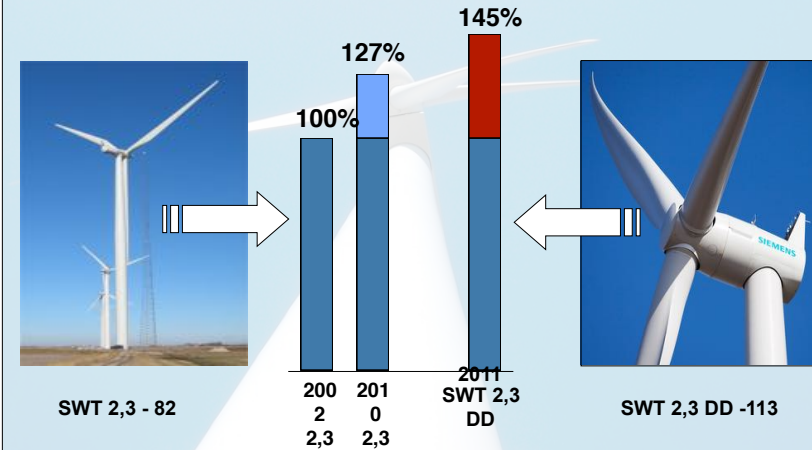
Experience of Onshore Wind Turbines



Note: Price data is unavailable for 2001, 2002, and 2003.
Data compiled by Bloomberg New Energy Finance.

5

Electricity production @ 7,5 m/s



By courtesy **SIEMENS**



7

DONG
energy

dongenergy.com

DONG Energy's offshore wind turbines break records

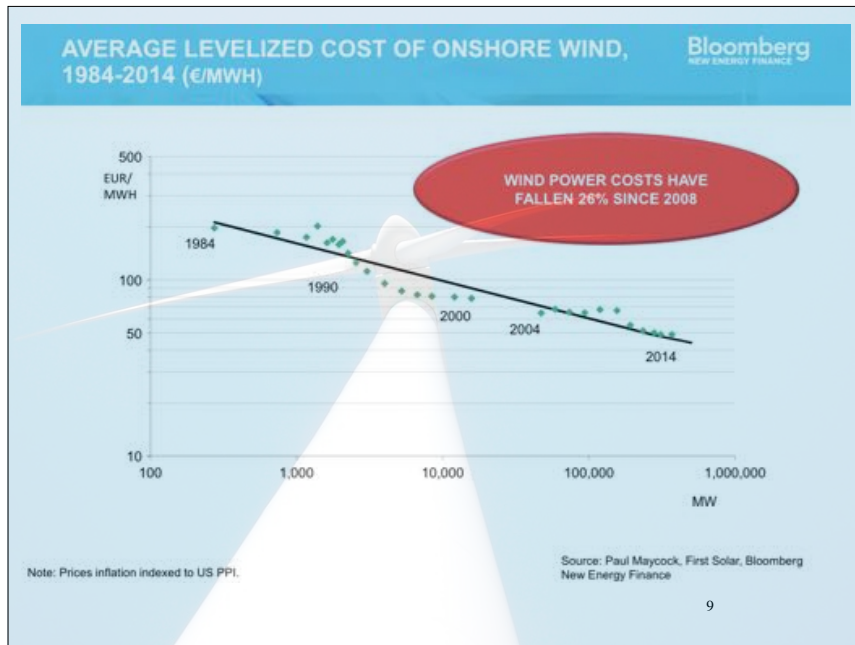
DONG Energy's offshore wind farms set a new record in January – and then again in February.



Anholt Offshore Wind Farm. Photo: DONG Energy



With a capacity factor of 70% in January and 71% in February, DONG Energy's fleet of offshore wind turbines had the highest production ever. Even though the winter months usually are more windy than the summer-months, the figures are extraordinary and it falls back on the work done by the DONG Energy employees working offshore.



2012
Average price of new wind power **4 cent/kWh.**

Taking into account the Production Tax Credit, the price was **6,2 cent/kWh (43 öre/kWh)**

10

2013
Average price of new wind power **2,5 cent/kWh.**

Taking into account the Production Tax Credit, the price was **4,7 cent/kWh**

10

2014
Average price of new wind power **2,35 cent/kWh.**

Taking into account the Production Tax Credit, the price was **4,55 cent/kWh**

10

2014

Wind Now Cost Competitive With Coal in India

By Katherine Tweed
Posted 23 Jul 2013 | 21:29 GMT

In India, the expiration of some federal incentives for renewable energy last year has not put a damper on the outlook for wind and solar power.

Wind power is now cost competitive with new coal-fired generation in India, according to a report from HSBC (<http://natgrp.files.wordpress.com/2013/07/india-renewables-good-bye-winter-hello-spring-hsbc-report.pdf>) [pdf]. Falling costs are just one reason for the increased interest in wind. For the first time, India has identified water as a scarce natural resource in its most recent five-year plan. Nearly 90 percent of India's industrial water demand comes from thermal power plants, according to the HSBC report.



August 2015

Coal in India

European utility says wind now cheapest form of generation

By Giles Parkinson

The falling cost of renewables is not news to those who have paid attention to analysis from green-focused think tanks, or groups like Bloomberg New Energy Finance. But it is when a major European utility, with equal exposure to fossil fuels, wind, and hydro, says that onshore wind is the cheapest of any new utility scale technology.

That is the assessment of Portugal's EDP, which has around 24GW of generation, of which around 8.7GW is in onshore wind.

In a recent presentation to analysts, EDP's head of renewables Joao Manso Neto presented this slide below, which shows that the levelised cost of electricity of onshore wind in Europe is 20 per cent cheaper than gas and one third cheaper than coal. (The figure assumes 25 per cent wind capacity factor).

recent five-year plan. Industrial water demand comes from thermal power plants, according to the HSBC report.

August 2015

e360 digest

29 JUL 2014: DANISH WIND POWER TO BE HALF THE PRICE OF COAL AND NATURAL GAS BY 2016

Wind power has overtaken all other energy sources as the cheapest form of electricity in Denmark, with a cost roughly half that of coal and natural gas projected by 2016, according to an analysis by the Danish Energy Association (DEA). Home to major turbine manufacturers Vestas and Siemens, the country has been investing steadily in wind power since the 1970s and seems to be reaping the benefits of those investments now, analysts say. Electricity from two new onshore wind power facilities set to begin operating in 2016 will cost around 5 euro cents per kilowatt-hour, according to DEA calculations. Wind power would remain the cheapest energy option even if interest rates on wind power projects were to increase by 10 percent, the report found. The Danish government aims to meet 50 percent of the country's total electricity needs with wind power by 2020, and another 20 percent with other renewable sources. By 2050, the government aims to produce all electricity from renewable sources.

http://www.ens.dk/sites/ens.dk/files/info/total-kort-fremskrivninger-analyser-modeller/notat_-_2014_07_01_elproduktionsomkostninger_for_10_udvalgte_tek



Matthias Schalk
Frederikshavn, Denmark

August 2015

BloombergBusiness Now Reading: Wind Power Now Cheaper Than Natural Gas for Xcel, CEO Says

October 23, 2015 - 4:58 PM CEST Updated on October 23, 2015 - 10:49 PM CEST

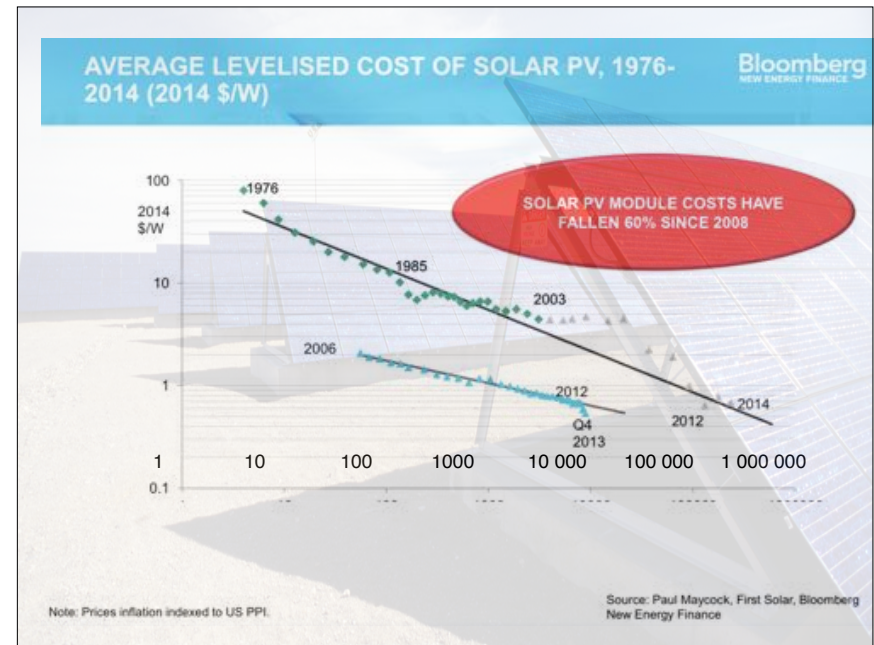
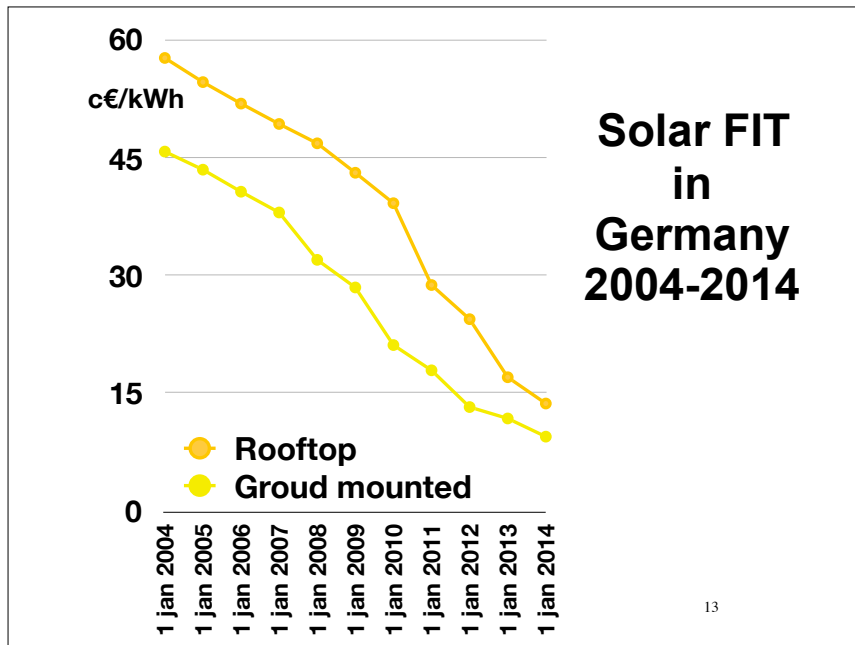
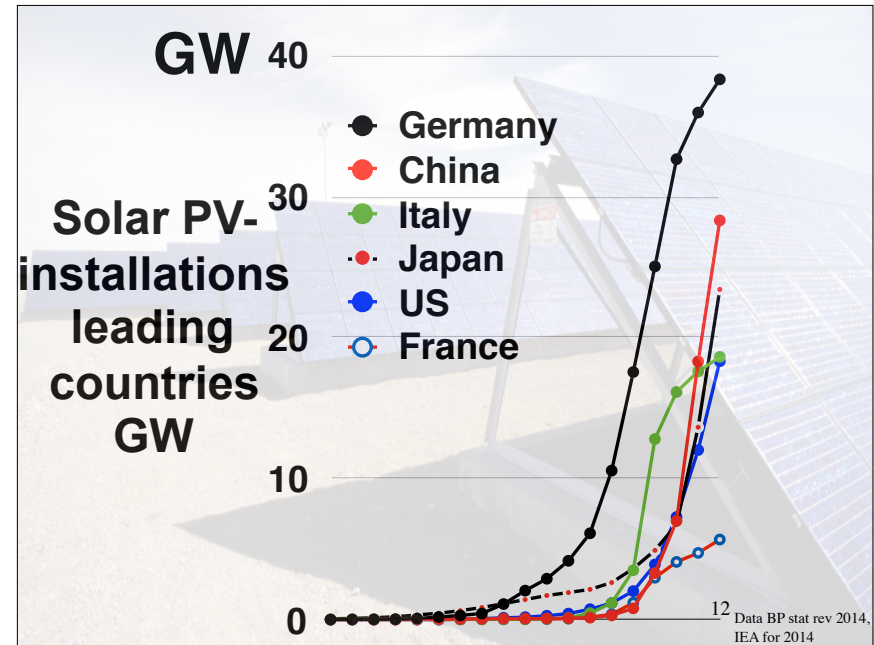
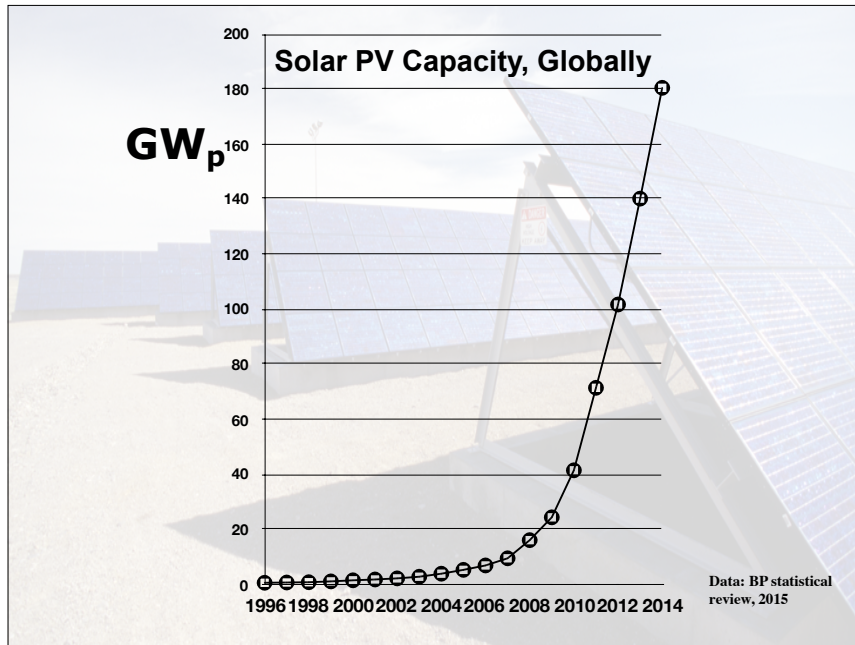
- ▶ Wind at \$25 over 20 years beats natural gas at \$32 for Xcel
- ▶ Utility planning to add 1,600 megawatts of wind capacity

Xcel Energy Inc., the biggest U.S. provider of wind power, expects long-term contracts for the technology to beat the cost of natural gas, another sign of the rapid transformation of the power market.

Xcel, the Minneapolis-based utility that serves eight states, is receiving bids for 20-year power-purchase agreements at about \$25 a megawatt-hour for wind energy, Chief Executive Officer Ben Fowke said in an interview Friday at Bloomberg News headquarters in New York.

While gas prices are close to historic lows, he doesn't see them remaining there forever, and Xcel expects prices for electricity from the fossil fuel to be closer to \$32 a megawatt-hour over the same period.

August 2015



Solar cheaper in India than imported Australian coal

By Sophie Vorrath on 28 October 2014

The results of India's latest solar auction are in, and it is bad news for developers of Australian coal projects – solar PV is cheaper for Indian users than the electricity price needed to pay for imports of coal from Australia.

A tender for 500MW of solar capacity in the sunny, south-eastern state of Andhra Pradesh, resulted in First Solar submitting the cheapest bids in an auction that was oversubscribed by more than double – 63 bids, totalling 1291MW in proposed solar developments.

First Solar submitted bids of just over 8 cents US per kilowatt-hour – \$0.086/kWh for 40MW and \$US0.087/kWh for another 40MW. In local currency terms the bids came in at INR5.25/kWh and INR5.35. That is significant, because it is below the price required to make coal imports economically viable.



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Brazil Brings In Low-Cost Solar Power (In Detail)

November 5th, 2014 by Anand Upadhyay

Last week Brazil entered the solar sector with a bang, after releasing contracts totalling 1048 MW spread over 31 solar parks. This would call for an investment of over \$1.66 billion. Most importantly, the average price of these solar projects was very low. In this piece, we take a look at the growth of solar power in Brazil and what might be in store for future.

A ceiling of \$106/MWh had been set on the solar electricity price. However, when the project developers started reverse bidding, the average price of electricity (for the 1048 MW worth of projects which will see the light of day, pun intended) came down to \$89/MWh. That's very low, lower than what fossil fuels or nuclear can offer.

89 USD/MWh ≈ 65 öre/kWh

Dubai Confirms 800 MW Expansion For Iconic Solar Power Project


April 27th, 2015 by Smriti Mittal

What do you think about this?

▲ Interesting 4 ▼ Not Interesting

The Dubai Electricity and Water Authority has initiated the third phase of its iconic Mohammed bin Rashid al Maktoum Solar Park.

The third phase of the solar park expansion will include a capacity addition of 800 MW. Dubai Electricity and Water Authority (DEWA) kick-started the tendering process for the expansion last week. The solar park will eventually be expanded to have an installed capacity of 3 GW.



The first phase of the solar park involved the installation of 13 MW capacity, and through the second phase tender, 100 MW capacity was famously auctioned to Saudi Arabia's ACWA Power at record-low average tariff of 5.84¢/kWh. The capacity awarded to ACWA Power was subsequently doubled, while the debt financing deal for the second phase expansion has been closed and the capacity is expected to be commissioned by 2017.

in the project MW worth of that's very low, lower than 2/kWh

Cheapest Solar Ever: Austin Energy Gets 1.2 Gigawatts of Solar Bids for Less Than 4 Cents

April 27th, 2015

"We expect to see prices out in the future that are possibly below \$20 a megawatt-hour."

Stephen Lacey
June 30, 2015

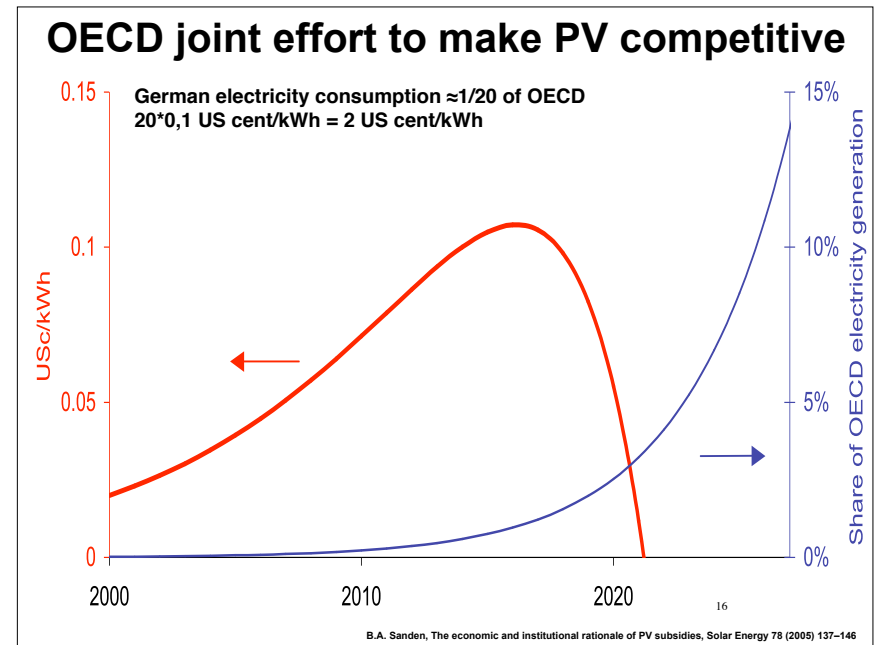
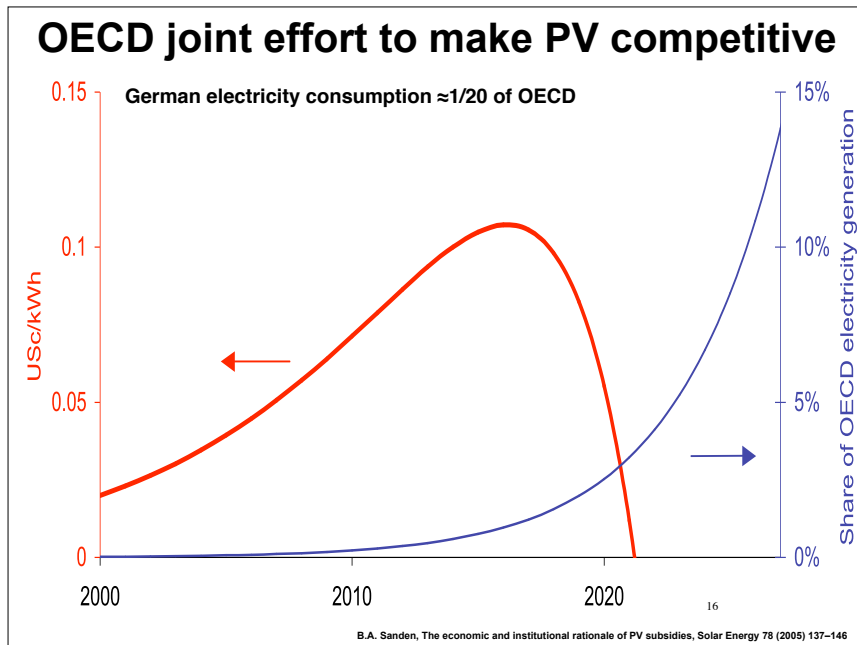
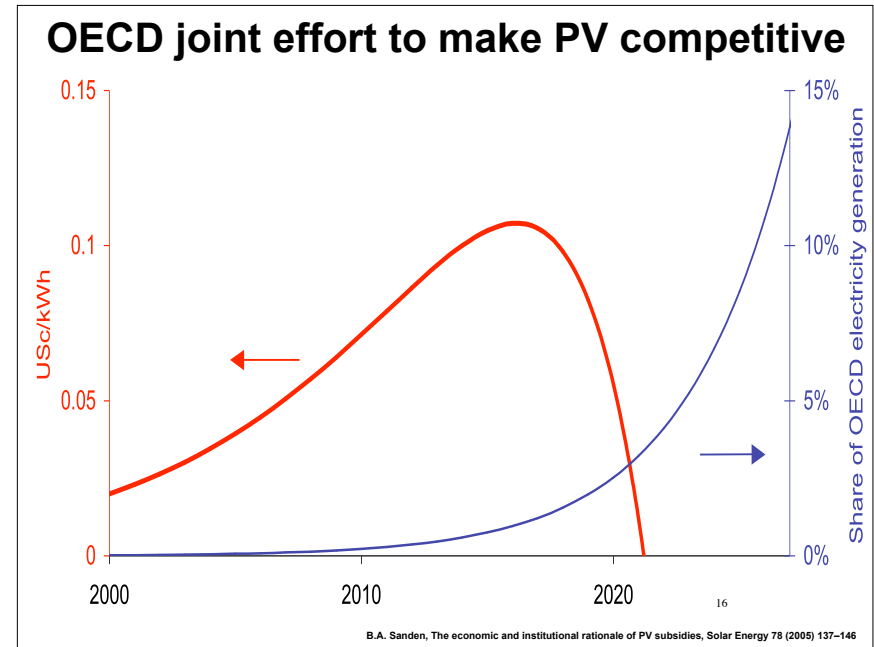
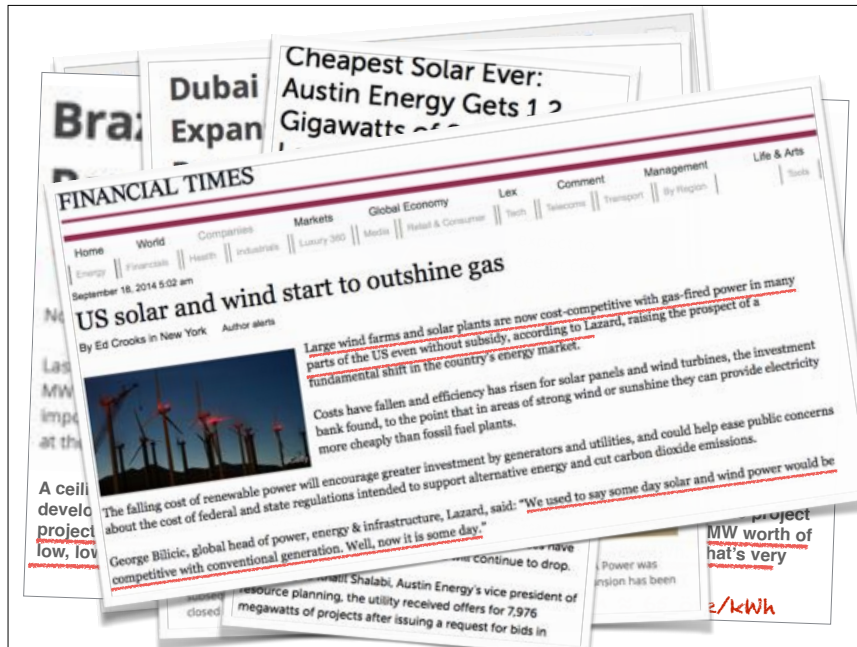
A lot more cheap solar is coming for Austin, Texas.

The city's utility, Austin Energy, just released new data on developer bids for PV projects as part of a 600-megawatt procurement. The numbers show how far solar prices have come down over the last year -- and will continue to drop.

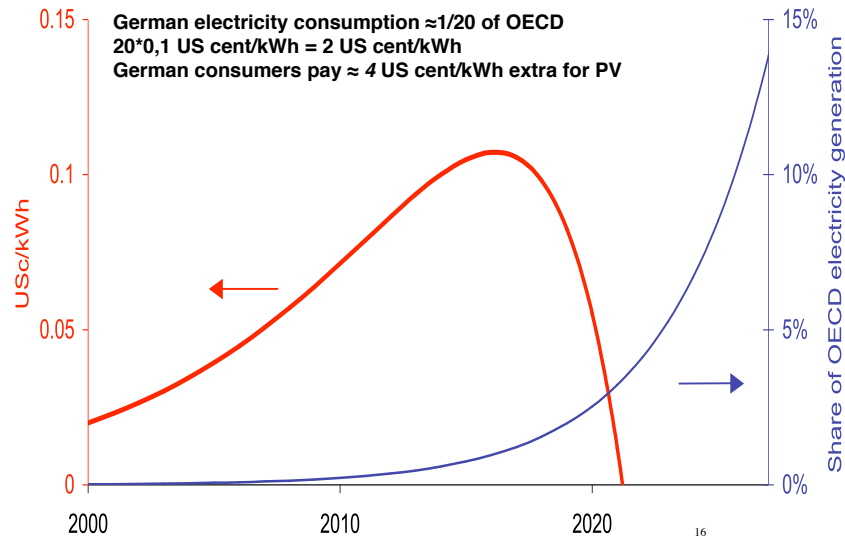
According to Khalil Shalabi, Austin Energy's vice president of resource planning, the utility received offers for 7,976 megawatts of projects after issuing a request for bids in

Power was auction has been

in the project MW worth of that's very low, lower than 2/kWh

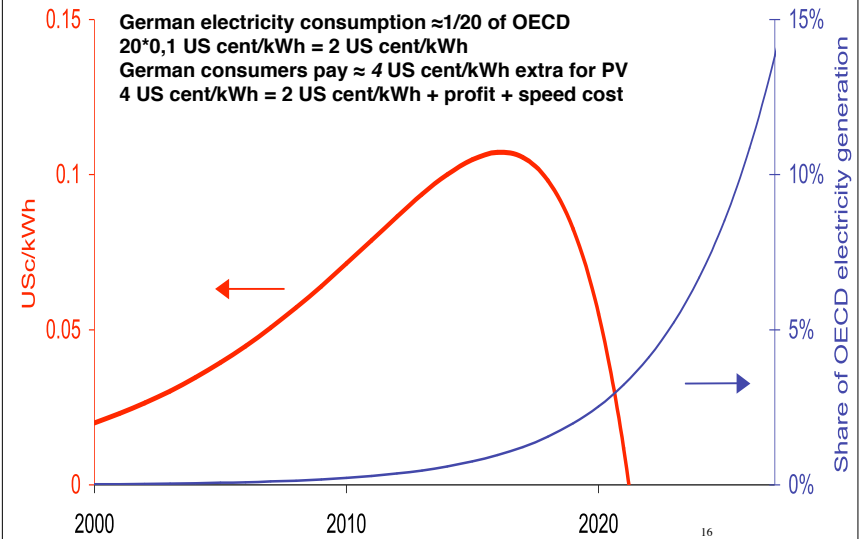


OECD joint effort to make PV competitive



B.A. Sanden, The economic and institutional rationale of PV subsidies, Solar Energy 78 (2005) 137–146

OECD joint effort to make PV competitive



B.A. Sanden, The economic and institutional rationale of PV subsidies, Solar Energy 78 (2005) 137–146





In Japan, one solar roof-top is installed every 2 minutes!



<http://www.solarbuzz.com/resources/articles-and-presentations/ro-residential-demand-approaching-1-gw-annum-8> & <http://www.sak.ingresearch.jp/research/ro-residential-demand-approaching-1-gw-annum-8>
http://www.j-pec.or.jp/information/doc/pdat_h24koufu_20130522.pdf

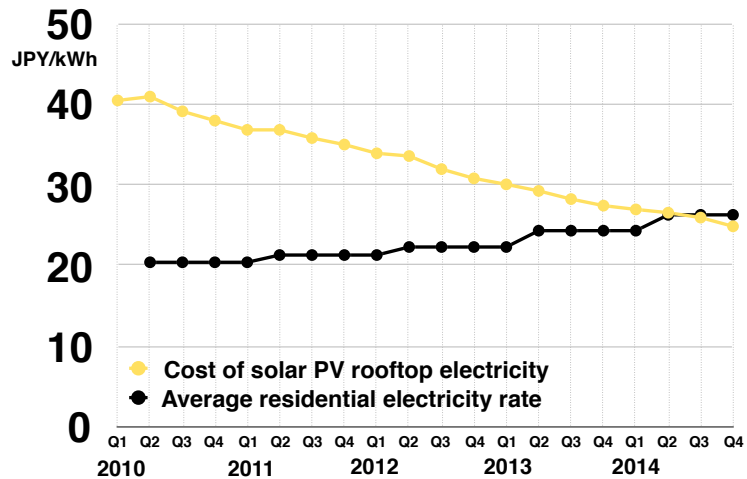


In Bangladesh, one solar roof-top is installed every minute!



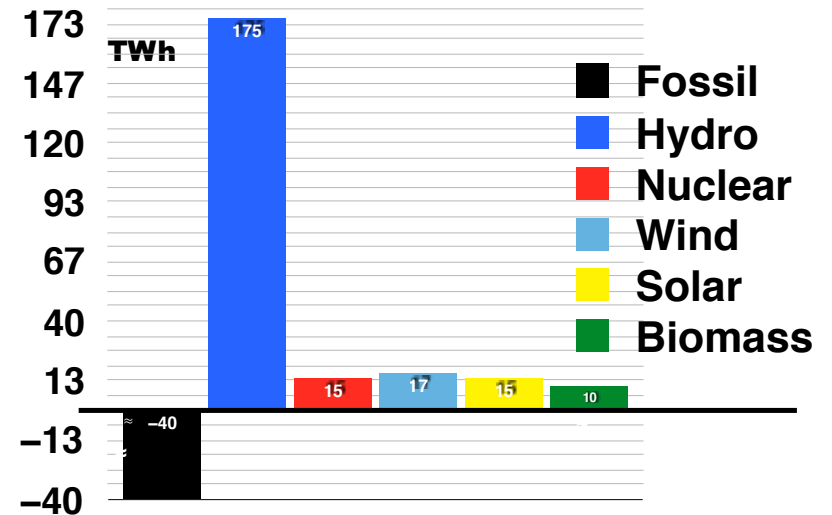
<http://www.solarbuzz.com/resources/articles-and-presentations/ro-residential-demand-approaching-1-gw-annum-8> & <http://www.sak.ingresearch.jp/research/ro-residential-demand-approaching-1-gw-annum-8>
http://www.j-pec.or.jp/information/doc/pdat_h24koufu_20130522.pdf

Japan's solar progress



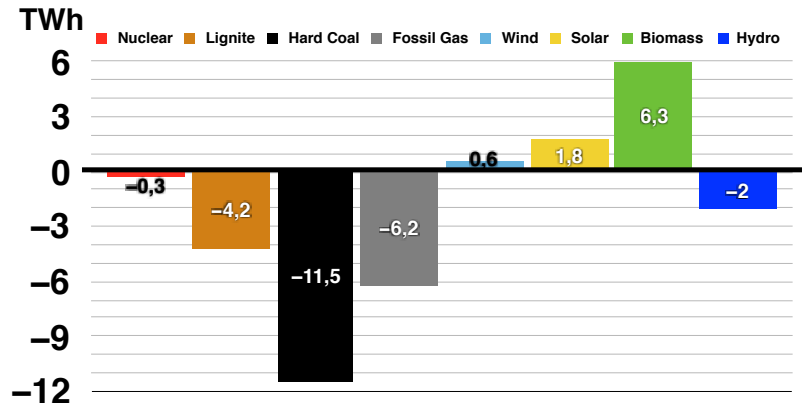
Assumptions for cost calculations:
 Capacity factor: 12%
 cost of capital: 1.7% (38 % equity 0.32 % rest 2.475%)
 Fixed O&M is 1% of the initial capital cost
 Dismantling cost is 5% of the initial capital cost.

Increased electricity production 2013-2014 in China



Data: <http://www.ccec.org.cn/guohuayutongji/gongxufenxi/dianliyunxingqiankuang/2015-02-02/133565.html> (uncertainties fossil biomass remains)

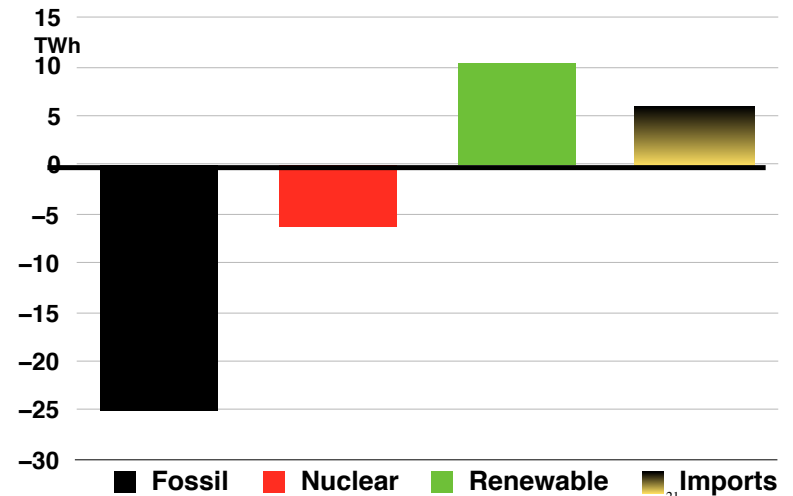
German change electricity generation 2013-2014



http://www.ise.fraunhofer.de/de/downloads/pdf_files/data/nivc/stromproduktion-aus-solar-und-windenergie-2014.pdf

20

UK electricity generation 2013-2014

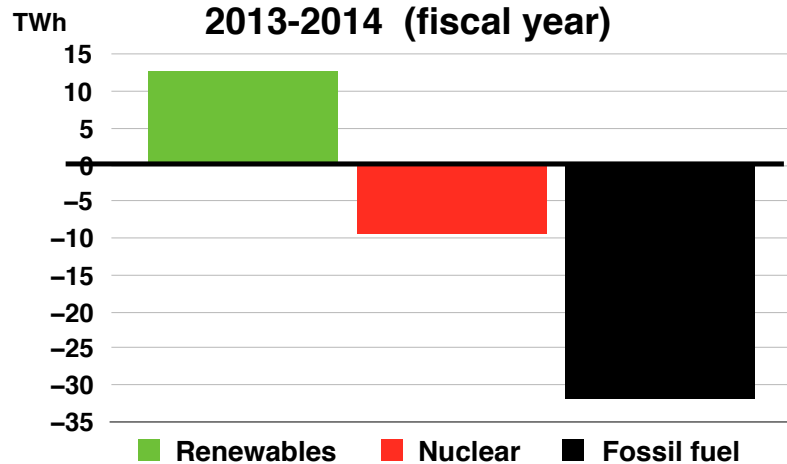


https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/415997/electricity.pdf

21

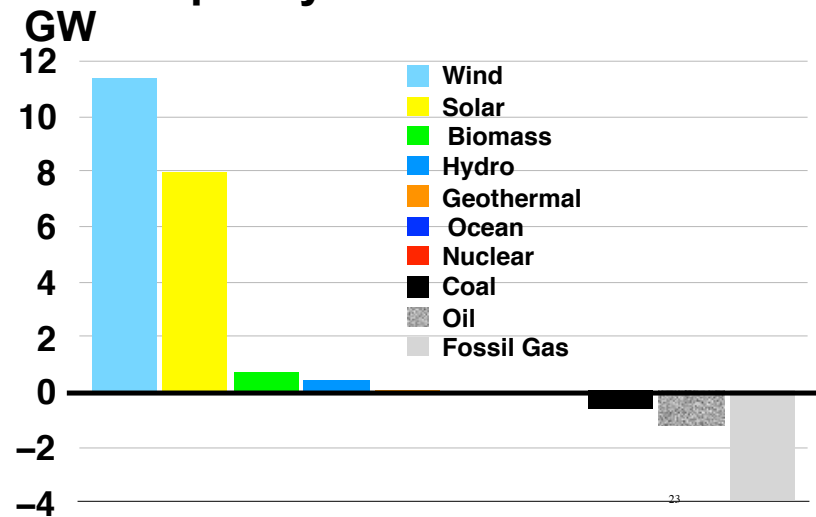


Change in Japan's Electricity Generation 2013-2014 (fiscal year)



Data: METI Electricity Research Statistics

New net electricity generation capacity in the EU 2014




Data: EWEA 2015

23

THE WALL STREET JOURNAL
 BUSINESS | September 17, 2013, 11:09 p.m. ET

Companies Unplug From the Electric Grid, Delivering a Jolt to Utilities

By REBECCA SMITH and CASSANDRA SWEET



On a hill overlooking the Susquehanna River, two big wind turbines crank out electricity for Kroger Co.'s Turkey Hill Dairy in rural Lancaster County, Pa., allowing it to save 25% on its power bill for the past two years.

Across the country, at a big food-distribution center Kroger also owns in Compton, Calif., a tank system installed this year uses bacteria to convert 150 tons a day of damaged produce, bread and other organic waste into a biogas that is burned on site to produce 20% of the electricity the facility uses.

These two projects, plus the electric output of solar panels at four Kroger grocery stores, and some energy-conservation efforts are saving the Cincinnati-based grocery chain \$160 million a year on electricity, said Denis George, its energy manager. That is a lot of money that isn't going into the pockets of utilities.

From big-box retailers to high-tech manufacturers, more companies across the country are producing their own power. Since 2006, the number of electricity-generation units at commercial and industrial sites has more than quadrupled to roughly 40,000 from about 10,000, according to federal statistics.

Experts say the trend is gaining momentum, spurred by falling prices for solar panels and natural gas, as well as a fear that power outages caused by major storms will become more common.


"The battle cry is Hurricane Sandy," said Rick Fioravanti, vice president of energy-storage technology at DNV Kerma, a Netherlands-based consulting company.

2013-2014

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2013-2014

THE WALL STREET JOURNAL
 BUSINESS | September 17, 2013, 11:09 p.m. ET

Vattenfall writes down \$4.6 billion in ailing energy market

By Anna Ringstrom and Gerrit Die Claes



(Reuters) - Vattenfall VATN UL, one of Europe's biggest energy companies, has written down the value of its business by 30 billion crowns (\$4.6 billion), seeing no prospect of a recovery in the region's ailing electricity markets.

UPDATE 2-NORDIC STOCKS - Factors to watch on July 18

Analysis & Opinion

Can EU infrastructure lead to a recovery in the region's ailing electricity markets?

2013-2014

THE WALL STREET JOURNAL
 BUSINESS | September 17, 2013, 11:09 p.m. ET

European utilities face an existential threat

From the print edition

ON JUNE 16th something very peculiar happened in Germany's electricity market. The wholesale price of electricity fell to minus €100 per megawatt hour (MWh). That is, generating companies were having to pay the managers of the grid to take their electricity. It was a bright, breezy Sunday. Demand was low. Between 2pm and 3pm, solar and wind generators produced 28.9 gigawatts (GW) of power, more than half the total. The grid at that time could not cope with more than 45GW without becoming unstable. At the peak, total generation was over 51GW, so prices went negative to encourage cutbacks and protect the grid from overloading.

Europe's electricity providers face an existential threat

How to lose half a trillion euros

Down the drain (\$4.6 billion)

recovery in the

2013-2014

THE WALL STREET JOURNAL
 BUSINESS | September 17, 2013, 11:09 p.m. ET

Press & News

Essen, 04 March 2014, RWE AG

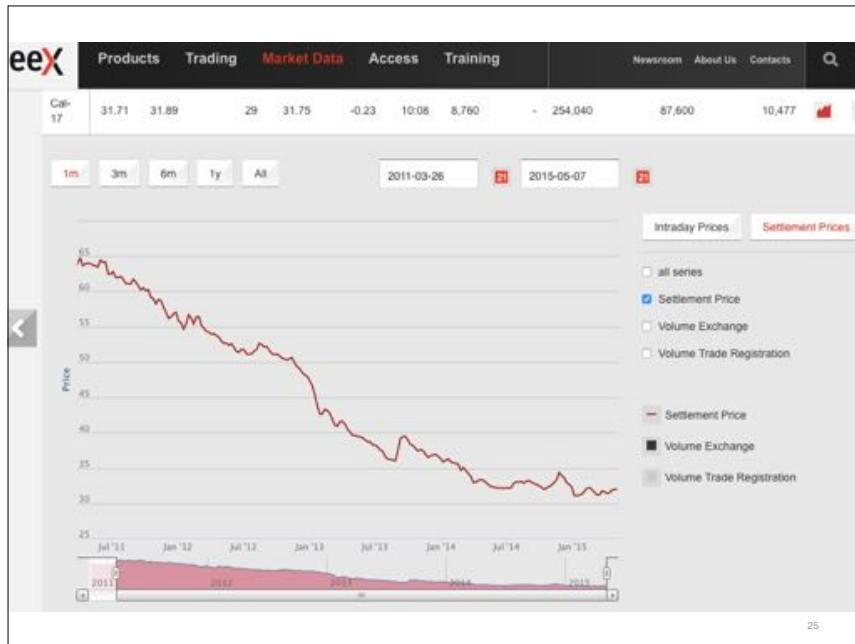
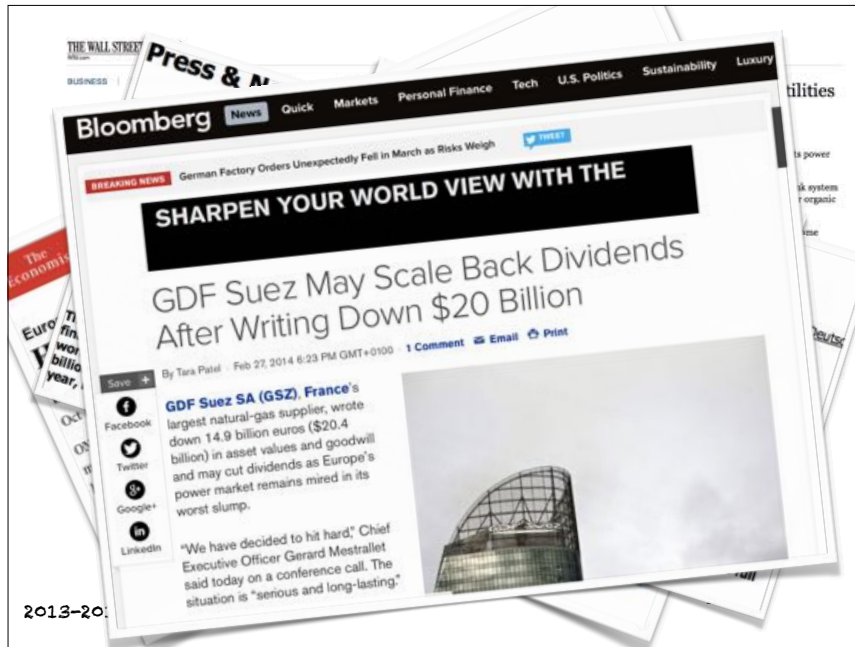
RWE posts first net loss in 60 years

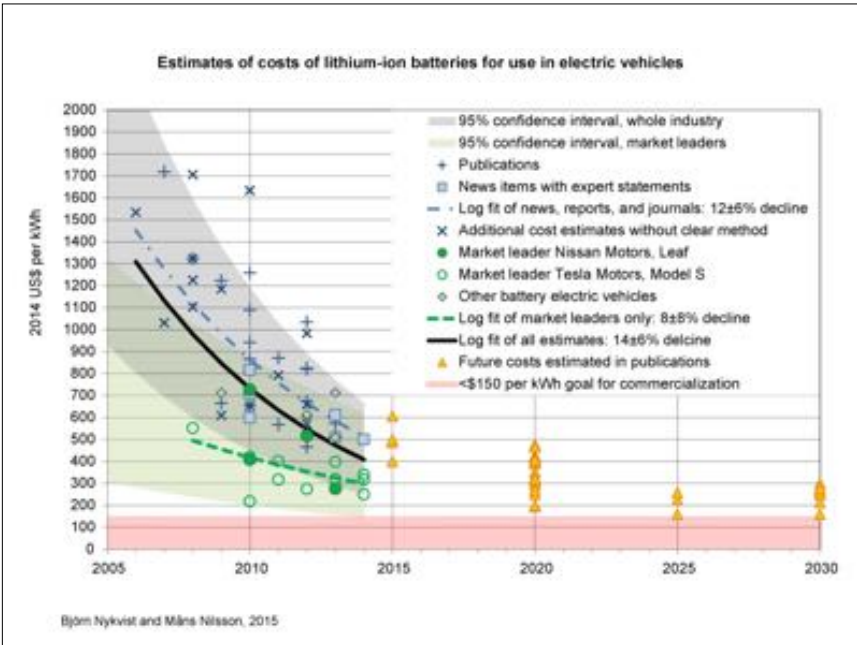
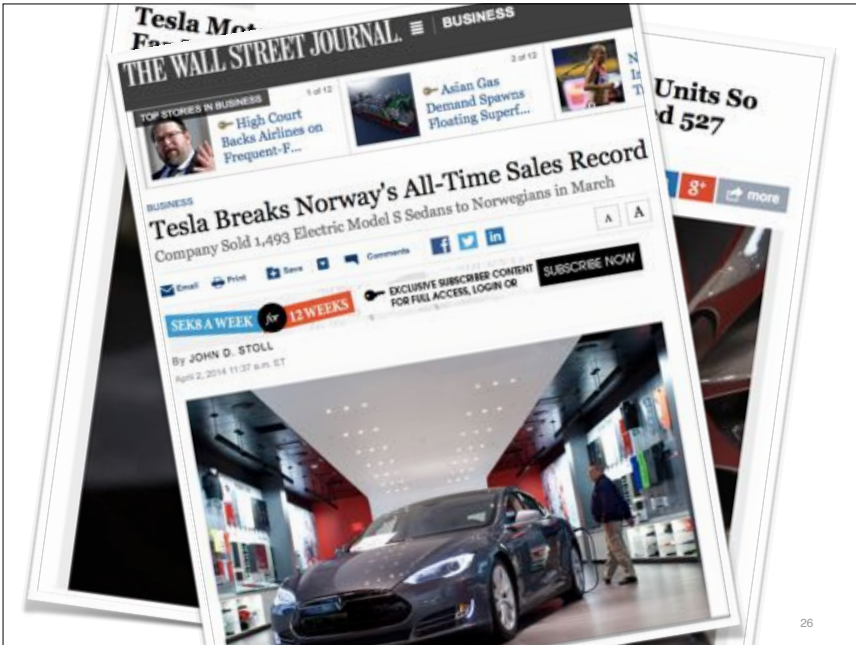
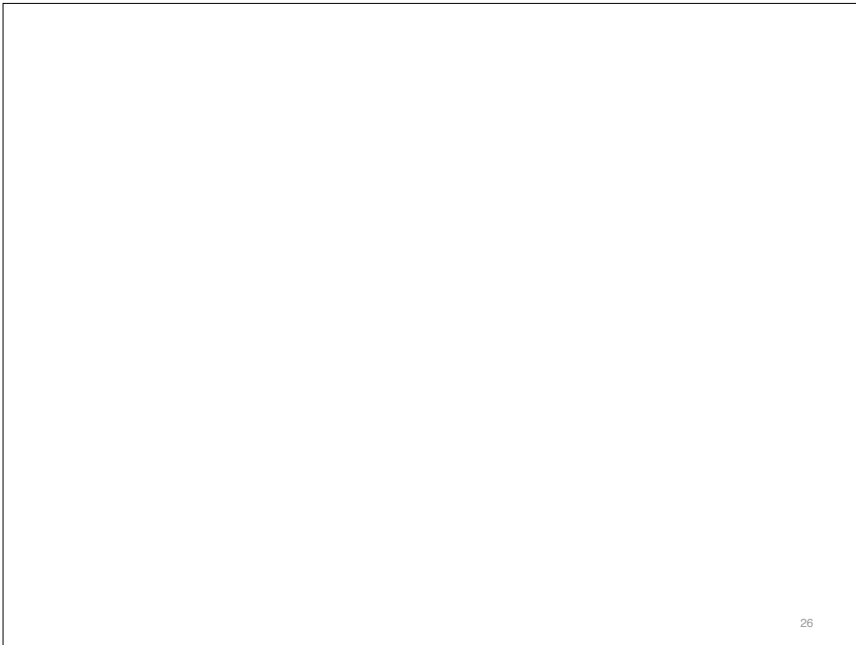
- Difficult earnings situation in electricity generation
- Efficiency-enhancement programme progressing faster than expected
- 2013 results in line with forecast
- Outlook for 2014 confirmed

The difficult earnings situation in conventional electricity generation in Europe is clearly reflected in RWE AG's financial results for fiscal 2013. For the first time since the Federal Republic of Germany was established, in other words, in more than 60 years, the Essen-based energy provider has posted a net loss amounting to -EUR 2.8 billion. This is attributable to impairment losses of some EUR 4.8 billion, which RWE had to recognise for the full year, mainly in respect of its power plant fleet.

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2013-2014





Setting a Course for Carbon-Free Shipping

<http://www.siemens.com/innovation/en/home/pictures-of-the-future/mobility-and-motors/electromobility-electric-ferries.html>



In conjunction with Fjellstrand, a Norwegian shipyard, Siemens has developed the technology for the world's first electrically-powered car ferry. The fact that the electric ship, which will enter service in 2015, causes no carbon dioxide emissions is in part due to the electricity mix in Norway.

As silently as a crocodile, the white giant approaches the shore. It opens its "mouth," which is several meters across. Suddenly the silence is broken by the roar of engines as a stream of trucks and people emerge from the opening. Odd Moen, an engineer who is responsible for ship solution sales at Siemens Norway, smiles. If everything goes as planned, this vision of an electrically-powered ferry sailing across Norway's fjords will become a reality at the beginning of 2015. Making hardly a sound and producing absolutely no emissions, it will be the first and only ferry of its kind in the world.

A Century of Battery-Powered Service

For more than 100 years, there have been battery-powered submarines that run solely on electricity.*

Text Size

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1 October 2014

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AIRBUS PUTS ELECTRIC E-FAN TRAINER INTO PRODUCTION IN PAU

Dave Calderwood May 1, 2015

Airbus is to put its two-seat E-Fan powered by electric motors into serial production in Pau, France. Construction on a new plant will start in 2016 and Airbus has set a target for entry-into-service for the E-Fan 2.0 of the end of 2017 or beginning of 2018.

<http://www.international-pilot.com/airbus-puts-electric-e-fan-train@9into-production-in-pau/>

https://www.youtube.com/watch?v=qfBfZJBQH_lf#t=30

<http://www.bloomberg.com/news/articles/2015-06-03/at-opec-the-saudi-oil-minister-mainly-wants-to-discuss-solar-power>



What does it say about oil when Saudi Arabia embraces solar?

by Timothy Coulter and Ryan Chilcote

June 3, 2015 - 6:15 PM CEST

[Social media icons]

Everybody wants to know what the oil minister for Saudi Arabia thinks. These days, it's all about solar power.

Fossil Fuels Just Lost the Race Against Renewables

This is the beginning of the end.



by Tom Randall

10:27 PM CEST April 14, 2015

[Social media icons]

The race for renewable energy has passed a turning point. The world is now adding more capacity for renewable power each year than coal, natural gas, and oil combined. And there's no going back.

The shift occurred in 2013, when the world added 143 gigawatts of renewable electricity capacity, compared with 141 gigawatts in new plants that burn fossil fuels, according to an analysis presented Tuesday at the Bloomberg New Energy Finance annual summit in New York. The shift will continue to accelerate, and by 2030 more than four times as much renewable capacity will be added.

The Development of Renewables

Collège de France 2015-10-30

Tomas Kåberger

Professor of Industrial Energy Policy at Chalmers University of Technology
visiting fellow/academy/professor at IAS TU München/IIIEE Lund Univ. / Zhejiang University
Executive board chair Japan Renewable Energy Foundation

The screenshot shows the IEA website header with the logo and tagline "Working together to ensure reliable, affordable and clean energy". The navigation menu includes HOME, ABOUT US, TOPICS, COUNTRIES, NEWSROOM & EVENTS, and PUBLICATIONS. The breadcrumb trail reads: International Energy Agency > Newsroom & events > Press Releases & News > News > 2015 > March. The main article title is "Global energy-related emissions of carbon dioxide stalled in 2014". The sub-headline states: "IEA data point to emissions decoupling from economic growth for the first time in 40 years". The date is "13 March 2015". The article text begins: "Data from the International Energy Agency (IEA) indicate that global emissions of carbon dioxide from the energy sector stalled in 2014, marking the first time in 40 years in which there was a halt or reduction in emissions of the greenhouse gas that was not tied to an economic downturn." A quote from IEA Chief Economist Fatih Birol is included: "This gives me even more hope that humankind will be able to work together to combat climate change, the most important threat facing us today," said IEA Chief Economist Fatih Birol, recently named to take over from Maria van der Hoeven as the next IEA Executive Director. The article concludes: "Global emissions of carbon dioxide stood at 32.3 billion tonnes in 2014, unchanged from the preceding year. The preliminary IEA data suggest that efforts to mitigate climate change may be having a more pronounced effect on emissions than had previously been thought." A "RECENT" sidebar on the right lists other news items.

Citibank: Utilities are dinosaurs waiting to die

By Jesse Berst
Published October 10, 2013

Tags: Corporate Strategy, Energy & Utilities, More...

[Email](#) | [Print](#) | [Single Page View](#)



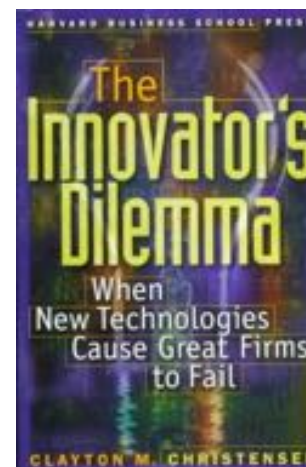
more quickly:

Today's electric power utilities could lose half their addressable market to energy efficiency, solar and storage, and other distributed generation, according to "Energy Darwinism – the evolution of the energy industry," a new report (PDF) from the investment banking arm of Citibank.

"Consumers face economically viable choices and alternatives in the coming years which were not foreseen five years ago," the analysts write.

According to *REneweconomy*, the price fall of solar panels has exceeded all expectations, resulting in cost parity being achieved in certain areas much

Disruptive innovations




☉ Solar and wind power are too expensive...

☉ Intermittent power is not sufficient...

☉ Solar and wind do not fit our business model...

Die Zeit, July 30, 1993

Wer kritisch fragt, ist noch längst kein Kernkraftgegner.



“Renewable energy, such as solar, hydro or wind in the long run cannot provide more than 4% of our electricity demand.”

Viele junge Leute empfinden Kernkraftwerke als bedrohlich. Wir, die deutschen Stromversorger, haben ihre Kritik nie leichtfertig abgetan. Im Gegenteil: Wir stellen uns dieselben Fragen, die sie bewegen.

Kann Deutschland aus der Kernenergie aussteigen? Ja. Die Folge wäre allerdings eine enorme Steigerung der Kohleverbrennung, mithin der Emissionen des Treibhausgases CO₂. Denn regenerative Energien wie Sonne, Wasser oder Wind können auch langfristig nicht mehr als 4% unseres Strombedarfs decken.

Können wir ein solches Vorgehen verantworten? Nein. Der steigende Energiebedarf der dritten Welt verpflichtet die reichen Staaten, ihre CO₂-Emissionen zu mindern.

Schaffen wir das ohne Kernkraft, allein durch Energiesparen? Nein. Kernkraftwerke liefern 34% des deutschen Stroms und ersparen der Atmosphäre jährlich 160 Mio. Tonnen CO₂ – bei einem international vorbildlichen Sicherheitsstandard. Also: Treibhaus oder Kernkraft? Das ist hier die Frage!

Viele junge Leute stellen kritische Fragen. Wir auch. Denn unsere schärfsten Kritiker sind wir selbst.

Ihre Stromversorger

36

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2013: Renewable energy provided 25% of electricity demand in Germany. (Solar alone: 5%.)

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