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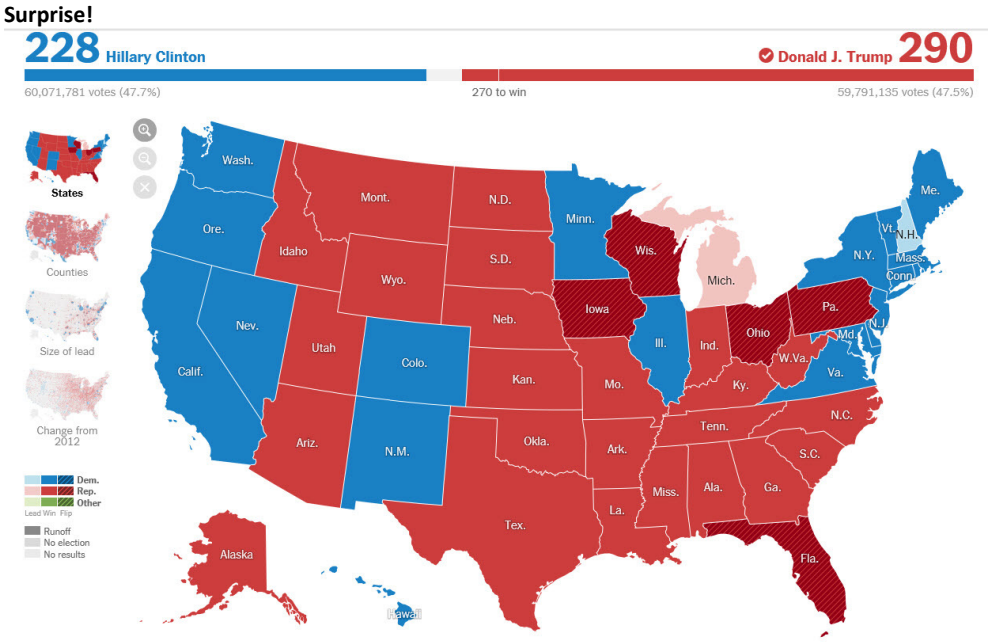
Surprise: In Politics Expect The Unexpected

Establishment politics and politicians increasingly challenged

Brexit was the first major political surprise of 2016. Few experts or pollsters saw it coming and many are still puzzled on why it happened and what will it mean for UK's business relations with the Continent. Many who voted for the UK to leave the **European Union** apparently did not actually expect that it could in fact happen. They were merely expressing anger and frustrations with the incumbent politicians, who many saw as elites out of touch with the ordinary folks. When they realized what had happened, many were surprised at what they had unintentionally done. Go figure.

The next big political surprise of 2016 – there were many – was the rejection of the **Colombian peace accord**, which took 4 years of hard bargaining. **Juan Manuel Santos**, the President of Colombia was so assured about the outcome of the referendum to ratify the treaty with the FARC guerillas that he organized formal ceremonies in Cartagena the week prior to the vote. By the narrowest of margins, the voters



Source: NY Times

rejected the deal. Some were apparently upset that Santos had taken their consent for granted before they had a chance to approve it – according to one explanation. Hmm…

By far, however, the biggest surprise of 2016 was the **US presidential elections** on 8 Nov (map on front page), which caught most pollsters off guard. Once again, it was a close race – some states were won by the smallest of margins imaginable – yet a surprising outcome. Now, everyone is trying to determine what the new occupant of the White House is going to do after the inauguration on 20 January 2017.

If one goes by the rhetoric of the campaign, major setbacks may be expected on the environmental front, potentially undoing much of what was achieved and/or attempted during the past 8 years. More surprises are likely to follow, including the potential fate of the **Paris Climate Accord** (article on page 8), painstakingly stitched together following over 2 decades of grueling negotiations.

As for **President Obama's** legacy, some of his harshest critics can now ask what legacy?

Nobody said democracy was easy or efficient. And apparently, it is no longer predictable. ■

IEA Finally Gets It: Renewables *Are* The Future

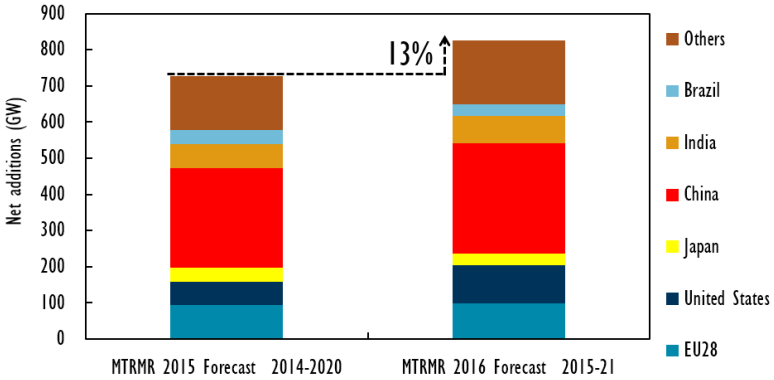
After successively underestimating, IEA finally concedes

The **International Energy Agency** (IEA) was founded in 1974 following the first **Arab Oil Embargo** to help its member countries co-ordinate a collective response to major oil supply disruptions. As an oil-centric organization, the IEA virtually ignored renewables for the first 2 decades of its existence – as if they did not exist or matter.

Starting in 2000, as climate concerns rose and renewables began to enjoy sustainable growth in several important markets, IEA was forced to acknowledge their existence, however slowly and grudgingly. In the last decade, as costs of renewables continued to drop and climate change took center stage as an important global issue the IEA began to take notice – but not wholeheartedly at first.

In the past few years, renewables could no longer be treated as incidental to the global energy system as they moved mainstream, competing head on with fossil fuel and nuclear energy on cost even in the absence of an explicit **carbon price**. Then came **COP21** agreement in Paris in December 2015 – now officially ratified as a treaty, demonstrating the global resolve to address climate change, although many details are yet to be spelled out (article on page 8). That, you might say, was the game changer.

Jack up renewable forecast by 13%: Will that be enough?
Renewable electricity capacity growth (GW) in *MTRMR's main case*



Source: Medium-term renewable energy market report 2016, 25 Oct 2016, IEA

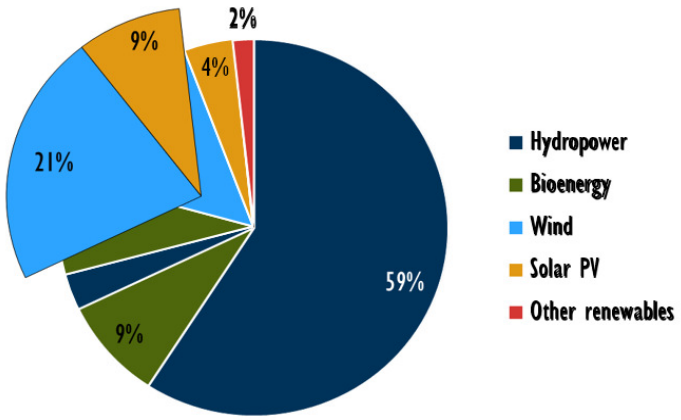
Moving forward, not only are renewables moving to center stage but they are increasingly seen as an integral part of any solution to combat climate change. IEA, like all other major energy organizations, has taken notice. It says, the agency's mission has evolved and rests today on three main pillars: working to ensure global energy security; expanding energy cooperation and dialogue around the world; and promoting an environmentally sustainable energy future. Oil is not even mentioned.

How to deal with future oil supply disruptions do not seem to be an urgent, or even a relevant issue now. The problem with oil – at least for now – is too much supply, depressed prices, and sluggish demand growth. Add rising concerns about climate change and the IEA's new *raison d'etre* becomes clear.

Against this background, the IEA released its **Medium-Term Renewable Market Report** in late October 2016, with a more renewable-friendly posture. Its Executive Director, **Fatih Birol** said,

> "I am pleased to see that last year was one of records for renewables and that our projections for growth over the next 5 years are more optimistic," adding, "However, even these higher expectations remain modest compared with the huge untapped potential of renewables. The IEA will be working with governments around the world to maximize the deployment of renewables in coming years."

Hydro grows too, but not as fast as solar & wind
Renewable electricity generation by source 2021



Source: Medium-term renewable energy market report 2016, 25 Oct 2016, IEA

That certainly is a new twist: IEA not only acknowledging renewables but working with governments around the world to maximize their deployment?

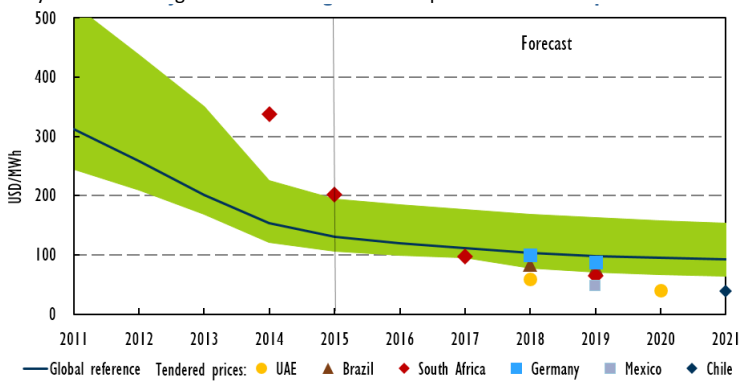
The same report says,

> "Renewables will be the fastest-growing source of electricity but growth still concentrated in wind and solar PV, and government support remains critical."

The new reality of renewables can no longer be dismissed, as acknowledged by the IEA:

> "Renewables have surpassed coal last year to become the largest source of installed power capacity in the world."

PV costs keep on falling
Utility-scale solar PV generation cost and contract prices



Source: Medium-term renewable energy market report 2016, 25 Oct 2016, IEA

The IEA now sees renewables growing 13% more between 2015 and 2021 than it did in last year's forecast, due mostly to stronger policy support in the **US, China, India** and **Mexico** – all key growth markets. Over the same period, costs are expected to drop by a quarter in solar PVs and 15% for onshore wind (see article on wind on page 10).

> "Last year marked a turning point for renewables. Led by wind and solar, renewables represented more than half the new power capacity around the world, reaching a record 153 GW, 15% more than the previous year. Most of these gains were driven by record-level wind additions of 66 GW and solar PV additions of 49 GW."

The facts speak for themselves. IEA is merely reporting the obvious:

> "About half a million solar panels were installed *every day* around the world last year. In **China**, which accounted for about half the wind additions and 40% of all renewable capacity increases, two wind turbines were installed *every hour* in 2015," according to the IEA.

Birol puts the two and two together when he says (emphasis added),

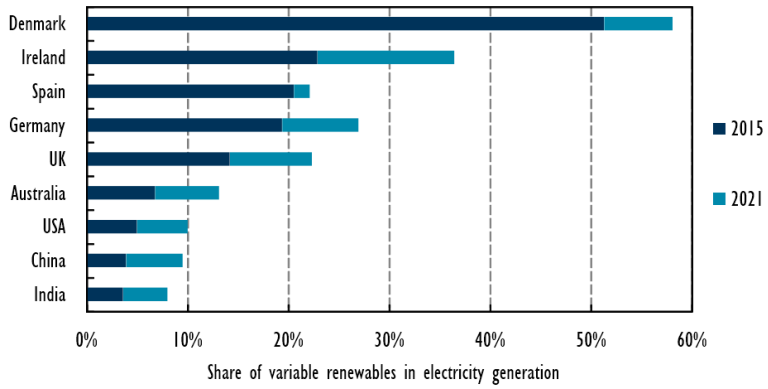
> "We are witnessing a **transformation of global power markets** led by renewables and, as is the case with other fields, the center of gravity for renewable growth is moving to emerging markets."

What are the main drivers of renewable growth? According to the IEA,

> "There are many factors behind this remarkable achievement: more competition, enhanced policy support in key markets, and technology improvements. While climate change mitigation is a powerful driver for renewables, it is not the only one."

Denmark in the renewable lead

Share of variable renewables in total electricity generation



Source: Medium-term renewable energy market report 2016, 25 Oct 2016, IEA

In terms of intermediate growth projections, the IEA says,

> "Over the next 5 years, renewables will remain the fastest-growing source of electricity generation, with their share growing to 28% in 2021 from 23% in 2015."

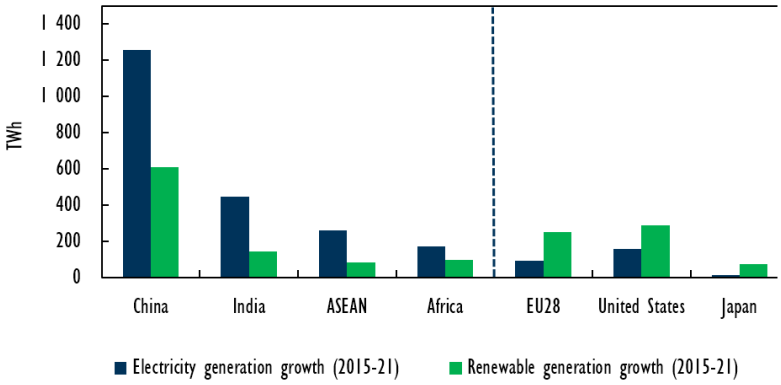
Adding,

> "Renewables are expected to cover more than 60% of the increase in world electricity generation over the medium term, rapidly closing the gap with coal. Generation from renewables is expected to exceed 7,600 TWh by 2021" – that is equal to the combined current electricity generation of the US and the EU.

The IEA points out the bifurcation of renewables among the *developed* and *developing* economies – both of which are expected to add significant new renewable capacity over time.

Two worlds

Electricity and renewable generation growth by country/region



Source: Medium-term renewable energy market report 2016, 25 Oct 2016, IEA

- In the former case – say in the **EU, US**, and **Japan** – additional renewable generation will *outpace* electricity demand growth between 2015 and 2021 – which suggests it will increasingly displace old, dirty and inefficient thermal generation;

- In the latter case, renewable growth only covers a portion of the region's fast-paced rise in electricity demand – which means the developing countries will end up with a cleaner energy mix over time.

A case in point: "**China** alone is responsible for 40% of global renewable power growth, but that represents only half of the country's electricity demand increase," the IEA notes.

The IEA identifies several policies that would boost renewable growth roughly 30% in the next 5 years, leading to an annual market of around 200 GW by 2020. It says this "would put the world on a firmer path to meeting long-term climate goals," a welcomed outcome given the recent ratification of the **Paris Accord** (article on page 8).

To its credit, the IEA has changed over time, however slowly. It is now trying its best not only to embrace **renewables**, but also **energy efficiency** as bona fide sources of energy. It is no longer oil-centric – as originally designed. Under its new Executive Director, it has taken major steps to reorient itself to remain viable – and relevant – in a world, which is still concerned about energy security but also climate and sustainability.

Whether IEA's upward projections on renewable growth will turn out to be another major under-estimation remains to be seen. As the following articles suggest, renewables have reached a stage of maturity that beats fossil fuels on cost and is superior on carbon footprint. Variability remains an issue, but not an insurmountable one. ■

IEA Report

Solar: Bigger Is Cheaper

Economies of scale favor utility-scale solar plants; even more so for storage

When the editor of this newsletter was working at **Southern California Edison Company** (SCE) in the 1980s, the company built **Solar One,** an experimental 10 MW **central solar power** (CSP) plant with funding from the DOE and EPRI. The biggest installation of its kind at the time, it was heralded as a new wonder of the modern world, receiving all sorts of acclaim, attracting dignitaries and VIPs from world over to stand in awe looking at computer controlled heliostats and the tower that converted sunlight's heat into steam to turn the turbines.

Fast forward to 2016 and a proposal to build **Sandstone**, a 2 GW CSP at a site yet to be selected somewhere in the Nevada desert. If it comes to pass – the project is yet to find financing, select and get approval for its site, secure power purchase agreements to sell the output of the plant, find transmission interconnection, etc. – it would dwarf Solar One 200 times over while producing power at a fraction of the cost. The giant plant would reportedly occupy 15,000 acres of land with 10 collecting towers and cost an estimated $5 billion (artist rendering on page 6).

While many details remain speculative, it is likely to use molten salt, which can be heated to 1,000 degrees F and stored, allowing the plant to operate at partial capacity after the sun goes down – a huge bonus since peak demand in California usually occurs hours after the sun sets.

Pitching his proposal – which faces multiple hurdles – **Kevin Smith**, the CEO of **SolarReserve** said, "We are presenting this to the California market as a more viable option than trying to deploy hundreds of thousands of individual batteries." It is a clever sales pitch, forget solar generation; focus on the plant's storage potential. Think what 2 GW of storage would mean to California's growing *duck curve* (graph on page 7).

Regardless of the merits of SolarReserve's proposal, there is universal agreement that utility-scale solar plants, whether CSP or PV, are significantly cheaper than the distributed variety – the small-scale solar installations on individual rooftops. Even more so for utility-scale storage, as this project is trying to do. When economists talk of "*economies of scale*," that is what they are talking about. Bigger *is* far cheaper on a per-unit basis.

Big storage: 2 GW of power from the sun plus storage after the sun sets
Artist rendering of proposed 2 GW CSP plant for Nevada desert

Source: SolarReserve

The current CSP record-holder is the 392 MW **Ivanpah plant** in Mojave Desert in Californian operated by **BrightSource Energy**. That plant, which has no storage, has had difficulties operating at full rated capacity. Reportedly, it uses natural gas to enhance its output – you might say cheating to reach its full contract rating. It has received quite a bit of negative publicity. It claims the problem has been rectified.

The point is not whether this particular CSP project will be built or not, but the fact that renewables, notably wind (article on page 10) and solar, are popping out at ever larger numbers and bigger scale virtually everywhere.

EcoNet News, for example, reported on the world's largest rooftop solar installation, 50,000 PV panels covering some 60 acres of rooftop with 16.4 MW of capacity (photo below right).

16.4 MW solar rooftop on scale: From idle roof to money making machine

Source: EcoNet News, 29 Oct 2016

The **Westmont project** is on a massive distribution warehouse in **San Pedro** near the **Port of Los Angeles**. Westmont is essentially leasing its idle roof to **PermaCity**, a solar developer for 20 years. "What had once been an unused asset will now generate tens of millions of dollars for Westmont," according to **Ted Flanigan**, the Editor of EcoNetNews and head of **EcoMotion**.

The rapid growth of solar is having other noticeable impacts, for example, in **Texas**, by spoiling the mid-day high prices, the bread and butter of thermal power generators.

As noted in the Oct 2016 issue of this newsletter, by some estimates, the **Lone Star state** may end up with massive new utility-scale solar PV capacity over the next decade – perhaps as much as its current wind capacity of 19 GW.

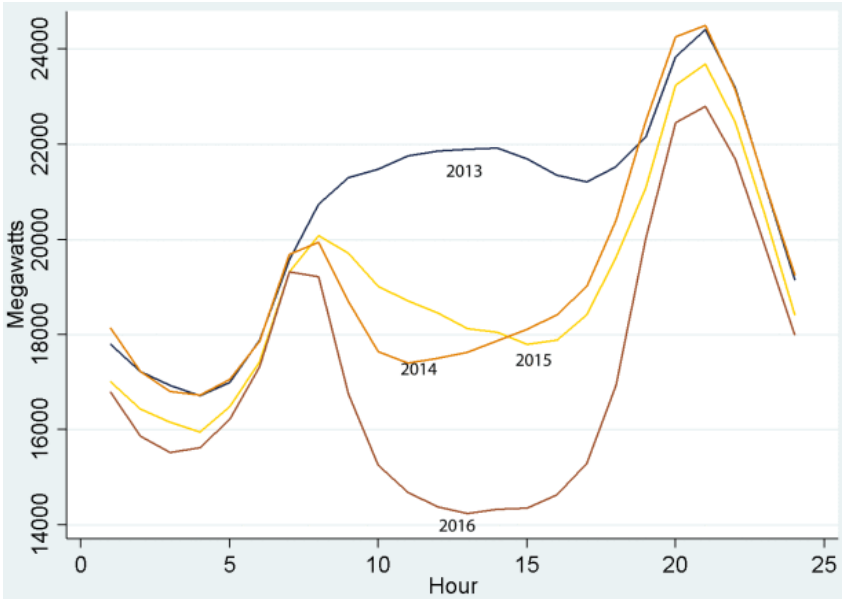
Cheap solar energy threatens to depress wholesale electricity prices during peak midday hours, when generators traditionally made good profits feeding the state's massive air conditioning load.

According to a recent report by **Bloomberg New Energy Finance** (BNEF) the growth of solar power will be the latest threat to the coal- and natural gas-fired generators in the Texas market, the **Electric Reliability Council of Texas** (ERCOT). Thermal generators, who have already been hurt by competition from abundant wind and stagnant demand now must contend with growing solar generation virtually vaporizing the mid-day peak prices.

Per BNEF's **Nicholas Steckler**, "The impact from the solar panels is going to be concentrated on those on-peak hours, when the prices have historically been higher," adding, "It's a significant hit to everyone."

Solar is expected to lower wholesale prices by as much as $2.50/MWhr during peak hours by 2020 in ERCOT's west hub, according to BNEF. It expects the addition of roughly 4 GW of solar capacity by the end of the decade, from 559 MW this year, thanks to cheap land and sunny conditions.

Storage goes a long way to address California's duck curve problem



Data taken from CAISO website. Graph summarizes hourly data, 28 March – 3 April, 2013-16
Source: Blog posted by M. Fowlie, 2 May 2016

"Just having this new influx of daytime energy production is going to bring down energy prices on average during the day," Steckler said.

The growth of renewables is being felt across the US and many parts of the world. **California Energy Commission's** (CEC) latest **Integrated Energy Policy Report** (IEPR), for example, declares that 23,600 MW of renewable capacity has *transformed* California's electricity system on multiple dimensions.

The CEC says demand forecasting should better reflect the evolving energy system associated with increases in **distributed energy resources** (DERs), **energy efficiency** (EE), and **electric vehicle charging**, among others.

California's renewable capacity has grown from 6,800 MW in 2001 to 23,600 MW in 2016, including roughly 5,000 MW from self–generation. Developments in California and Texas are merely two obvious examples of the rapid *transformation* of power industry – also acknowledged to by the IEA's **Fatih Birol** (Article on page 2). ■

COP22: Now Comes The Hard Part

Now that we've ratified the agreement, let's read the fine print

Celebrations were barely over at the **United Nations** on the successful ratification of the **Paris Accord**, COP21, when delegates began packing for Morocco to discuss the details of how to deliver on voluntary pledges made by countries, who now must begin to deliver results. The COP22, which began on 7 November in Marrakesh, **Morocco**, is focused on implementation of what has been agreed – namely how countries will translate their commitments into action.

First, celebrate then read the fine print

Source: Global Wind Energy Outlook 2016, GWEC, 2016

With energy contributing two thirds of global carbon emissions, the energy sector is at the heart of the climate challenge, and deliberations in Morocco. This newsletter was finalized before the end of COP22 – more on what was accomplished, or not, in Jan 2017 issue.

The focus of the debate has clearly shifted on the details of how various governments will or should be held accountable and how the measurement and monitoring of their achievements will be tallied with 2018 as the likely deadline, assuming no major surprises. That, of course, is a *big if* not only because the UN has a new head, but also because the US has elected a president who apparently does not believe in climate change. And should the US back away from the Paris Accord – according to one pessimistic scenario – the whole treaty is likely to suffer – which is what happened to **Kyoto Protocols**. ■

Tesla Energy: New Kid On The Block

Elon Musk unveils his integrated mobility, solar and battery solution under one roof

In late October 2016, **Elon Musk**, the CEO of **Tesla**, unveiled what his integrated mobility, solar roof and battery storage solution might look like – literally all under the same roof – that is an elegant solar roof integrated into the design of the house. It is a **building-integrated PV** or BIPV. In his characteristic hyperbole style, Musk claimed the new roof will cost less "than a normal roof plus cost of electricity" without further clarifications.

The cost of electricity, of course, varies from place to place, and so does how much solar energy one can get from the roof. Hence it is fair to assume that the new system would make sense in sunny places with high retail tariffs, say California or Hawaii.

As described in Sept 2016 issue of this newsletter, Musk has offered to acquire Tesla's sister company, **SolarCity**, the biggest US distributed solar installer with the intention of integrating mobility – **Tesla car** – distributed solar – **SolarCity** rooftop PVs – and storage – **Powerwall** – into a single company under **Tesla Energy** brand. And what a powerful brand that would be, if he can pull it off. With too many balls to juggle – all his companies are burning cash at fast pace – not everyone is convinced that he will be able to deliver on so many promises. Yet his ideas are simply too good to dismiss.

As Musk described it, the new roof system would integrate with the Powerwall 2.0 battery system, which could power the refrigerator, sockets and lights of a four-bedroom house for a day. Add the rooftop solar system and the house becomes virtually self-sufficient – except on extended cloudy periods when it must rely on the network. Musk envisions a future where *every* household has an electric car – a Tesla, of course – a battery – a Powerwall, of course – and a solar roof – installed by Tesla Energy, of course, on their home.

House of the future: Elegant, efficient and energy-sufficient

Source: Tesla unveils residential solar roof and new Powerwall battery, Utility Dive, 28 Oct 2016

According to Musk, incumbent electric utilities need not fear Tesla's new business model – there will be enough business to go around. The projected growth of electric vehicles would add to demand. In the long term, about one-third of the power needed for EVs will come from rooftop solar with the remaining supplied by the utilities, according to Musk.

Integrate solar into the design from start, rather than as an "add-on" later on

Source: Onyx

Many agree with Musk that future buildings, residential, commercial and industrial, will rapidly migrate into the so-called **building integrated designs**, where **energy efficiency**, **solar self-generation**, sophisticated **energy management and control systems** plus **storage** will be integrated into the initial design of buildings, rather than added later – resulting in major operational cost-savings over the long life of typical buildings.

As reported in the Oct 2016 issue of this newsletter, California's **zero-net-energy** (ZNE) mandate requires *new* residential buildings to produce as much energy as they consume starting in 2020; the same would apply to commercial buildings starting in 2030.

Already, a growing number of manufacturers including **Onyx**, a Spanish company, are offering a host of new products such as transparent PV windows (photo above) that can serve as roofing material for atriums, generating electricity while taking advantage of daylighting. The days of building a roof, and then adding solar panels on top of it are over.

Musk is among the entrepreneurs who are going to make a fortune offering such integrated solutions. ■

Utility Dive Article

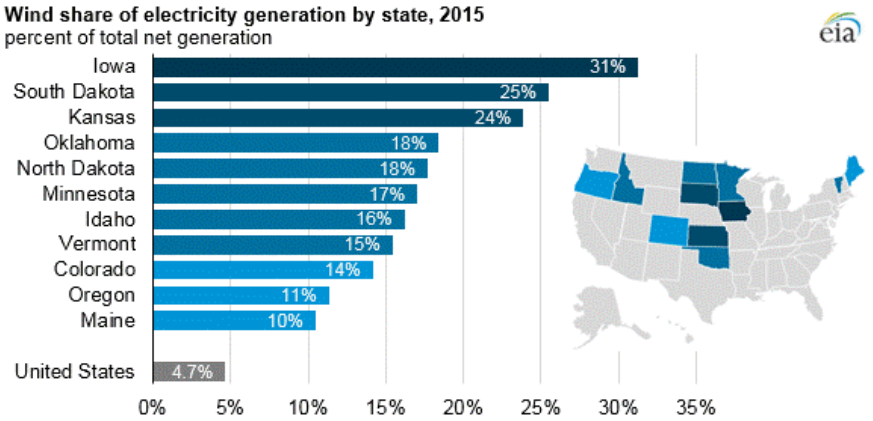
Onyx

Wind Can Deliver Far More

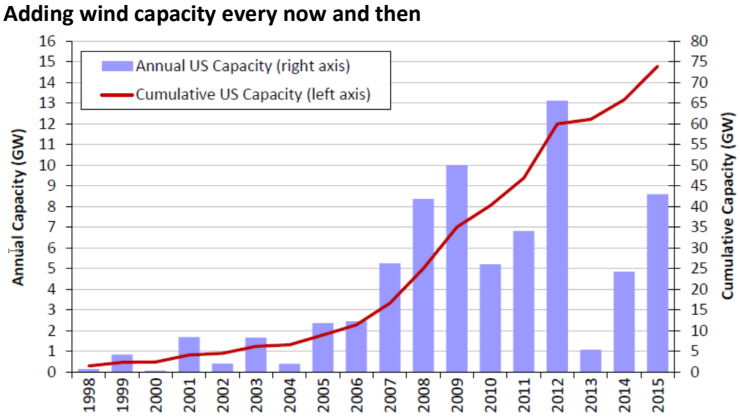
All indications suggest far more is yet to come

Wind, along with solar, are slated to be the 2 prominent contributors to new capacity additions the world over. That much is nearly universally agreed now. The question is how much, how soon, and at what cost. The short answer is more, sooner and most likely a lot cheaper than many expect.

Wind is already a major power generator in places like **Denmark, Germany** and **Ireland**, to name a few. According to the **Energy Information Administration** (EIA) in 2015, 11 states generated at least 10% of their total electricity from wind (graph on right) from 3 states as recently as 2010.



Source: U.S. Energy Information Administration, Electric Power Monthly

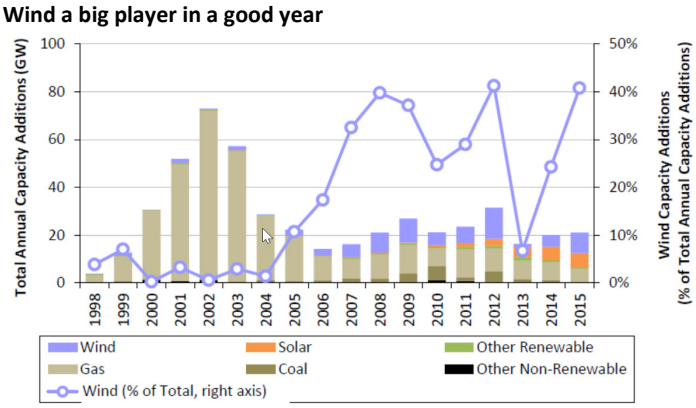


Source: 2015 Wind Technologies Market Report, US DOE, Aug 2016

Iowa had the largest wind generation share, at 31.3%, followed by **South Dakota** at 25.5% and **Kansas** at 23.9% with **Texas** and **New Mexico** on track to surpass the 10% milestone in 2016. Texas, the biggest wind producing state accounted for 24% of the US wind output and 9.9% of the Lone Star state's generation in 2015. For the US as a whole, however, wind currently accounts for less than 5% of total generation.

To get a sense of the growing role of wind in the US, the August 2016 edition of **Wind Technologies Market Report** by **Ryan Wiser** and **Mark Bolinger** of **Lawrence Berkeley National Laboratory** (LBL) is a perennial good read. Factual and comprehensive, it provides an assessment of technology and cost trends of a major renewable energy resource for the US, and anywhere else where the wind blows reliably – and that is nearly everywhere.

US continues to add wind capacity sporadically (Fig above), prompted by the rise and fall of financial incentives particularly the **production tax credit** (PTC), which is at the mercy of the US Congress for periodic extensions.



Source: 2015 Wind Technologies Market Report, US DOE, Aug 2016

China on top, and by a wide margin
International Rankings of Wind Power Capacity

Annual Capacity (2015, MW)		Cumulative Capacity (end of 2015, MW)	
China	30,293	China	145,053
United States	**8,598**	**United States**	**73,992**
Germany	6,013	Germany	44,986
Brazil	2,754	India	25,352
India	2,623	Spain	22,665
Canada	1,506	United Kingdom	13,388
Poland	1,266	Canada	11,190
France	1,073	France	10,243
United Kingdom	975	Brazil	9,346
Turkey	956	Italy	8,851
Rest of World	7,078	*Rest of World*	68,464
TOTAL	63,135	TOTAL	433,530

Source: 2015 Wind Technologies Market Report, US DOE, Aug 2016

In a good year, wind accounts for a significant percentage of *new* capacity additions in the US. As illustrated in Fig on bottom of page 10, in 2008, 2012 and 2015, for example, wind accounted for 40% of *all new* capacity additions. Not so in other years.

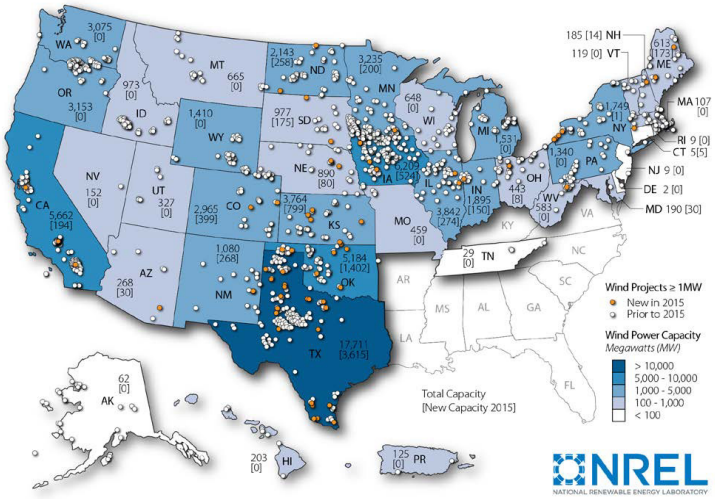
Since US does not need much new capacity, and with **coal** virtually out of the picture as a *new* resource, wind, gas and solar represent nearly all new additions over the past decade – a trend that is expected to continue.

With nearly 74 GW of installed capacity, US is surpassed only by **China**, which now boasts the biggest capacity of any country by a wide – and increasing – margin (table above). China added over 30 GW of new capacity in 2015, more than the total installed capacity of every country except the US and **Germany**. It now has over a third installed global wind capacity.

Denmark, Portugal and **Ireland** lead in wind energy penetration – measured in wind generation as % of total electricity consumption – US is 15th, China 20th.

Among the states, **Texas** continues to keep its lead – the latest estimate is around 19 GW. Except for the Southwest, where there is apparently little wind and even less political will to develop wind capacity, wind is prevalent nearly everywhere else (Fig above right)

Wind blows reliably nearly everywhere

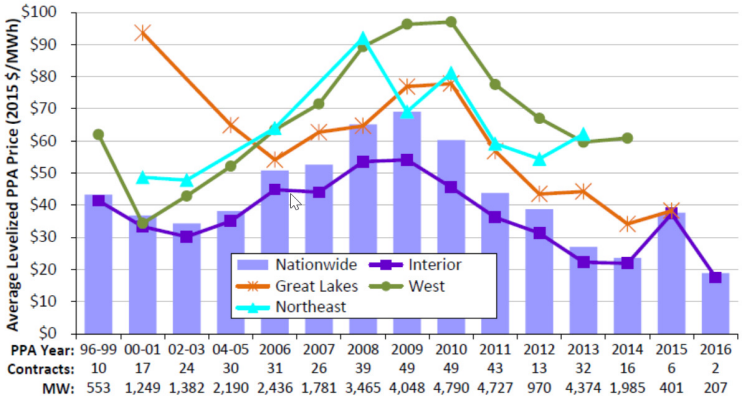


Source: 2015 Wind Technologies Market Report, US DOE, Aug 2016

The LBL's latest report documents improvements in performance of turbines, blades, gearboxes and capacity factor – reportedly exceeding 40% in 2015. That is impressive compared to much lower rates during the early, learning years where many wind farms were lucky to operate above 20% capacity factor.

The most important indicator, the **power purchase agreement** (PPA) price for contracts signed in recent years has fallen below $20/MWh or 2 cents/kWh – comparing nicely with the solar PV costs in the US and globally (Fig bottom of page 11). At such prices,

Cheap and clean power



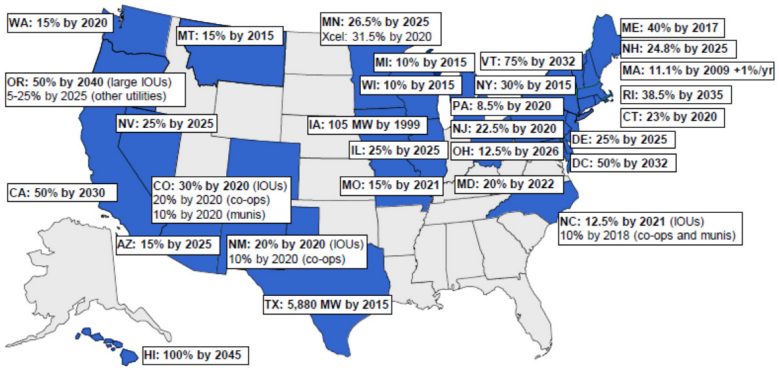
Source: 2015 Wind Technologies Market Report, US DOE, Aug 2016

wind is competitive. Of course, the production tax credit and other incentives help.

The LBL report indicates that wind has been mostly cost-competitive since 2011 in wholesale markets in the US depending on the price of natural gas, its biggest competitor.

The future of wind, like that of solar, is partly driven by state level policy decisions, most notably extensions of existing **renewable portfolio standards** (RPS), currently in effect in 29 states as indicated in map below as well as the extension of **production tax credit** (PTC) and other incentives. A carbon tax, if it were to pass, would help also.

Renewable portfolio standards generate demand



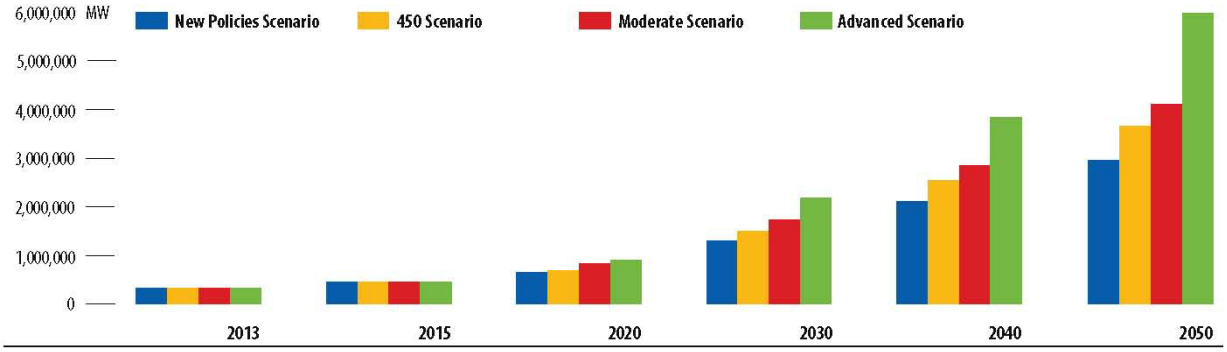
Source: 2015 Wind Technologies Market Report, US DOE, Aug 2016

In describing the outlook for wind, authors Wiser and Bolinger note,

"In 2015, the DOE published its *Wind Vision* report (DOE 2015), which analyzed a scenario in which wind energy reaches 10%, 20%, and 35% of US electric demand in 2020, 2030, and 2050, respectively."

According to the authors, "actual and projected wind additions from 2014 through 2020 are consistent with the pathway envisioned in the DOE report. Projected growth from 2021 through 2023, however, is well below the *Wind Vision* pathway."

Global wind: Pick your favorite scenario for 2030, 40, 50



	2013	2015	2020	2030	2040	2050
New Policies Scenario						
MW	318,354	432,656	639,478	1,259,974	2,052,583	2,869,611
TWh/a	714	868	1,569	3,311	5,394	7,541
450 Scenario						
MW	318,354	432,656	658,009	1,454,395	2,458,757	3,545,595
TWh/a	714	868	1,614	3,822	6,462	9,318
Moderate Scenario						
MW	318,354	432,656	797,028	1,675,624	2,767,351	3,983,995
TWh/a	714	868	1,955	4,404	7,273	10,470
Advanced Scenario						
MW	318,354	432,656	879,446	2,110,161	3,720,919	5,805,882
TWh/a	714	868	2,157	5,546	9,779	15,258

Source: Global Wind Energy Outlook 2016, GWEC, 2016

The conclusion? The US *can* technically achieve the DOE's vision of 10%, 20%, and 35% of US electric demand by 2020, 2030 and 2050, respectively, but this is "likely to require efforts that go beyond business as usual expectations," according to the authors. The next US president may not be keen.

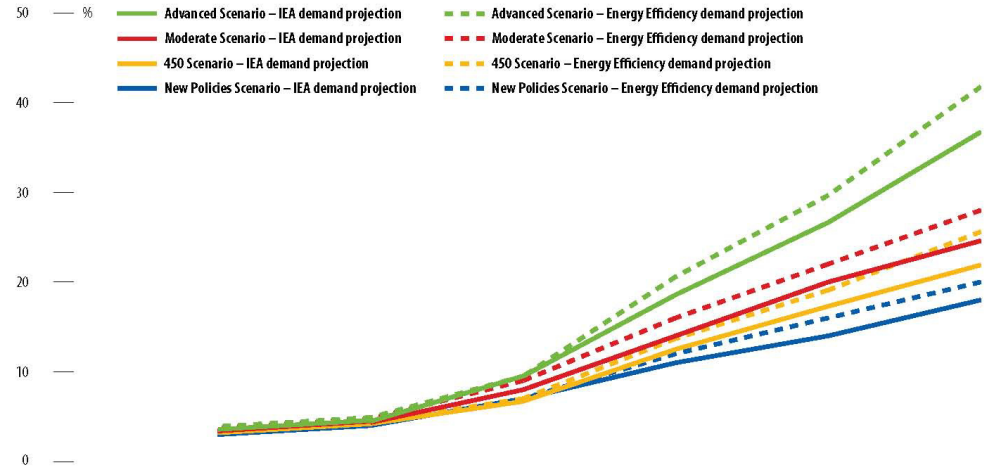
Regardless of what happens in the US, globally, wind is on a roll, per the **Global Wind Energy Council's** (GWEC) latest **biennial global wind energy outlook** released in late October 2016. It expects wind to supply 20% of global power by 2030 under a "favorable" scenario.

GWEC examines 4 scenarios for the future of wind industry to 2020, 2030 and 2050 (graph on page 12). It says global wind capacity could rise from about 433 GW in 2015 to 1,260 GW by 2030 and 2,870 GW by 2050 under the New Policies scenario with generation rising from 868 TWh to 3,310 TWh in 2030 and 7,540 TWh in 2050.

These are staggering numbers. One explanation for the projected growth of wind is dropping prices. The more they drop, the higher the projected penetration, as illustrated in visuals and accompanying tables below.

In the 450 Scenario – referring to 450 parts per million CO2 concentration in the atmosphere considered by the **International Energy Agency** (IEA) and others – wind capacity could reach 1,454 GW (3,822 TWh) in 2030 and 3,545 GW (9,318 TWh) in 2050. It could rise to 1,676 GW (4,404 TWh) by 2030 and to 3,984 GW (10,470 TWh) by 2050 in the Moderate Scenario and even reach 2,110 GW by 2030 and 5,805 GW by 2050 in the Advanced Scenario.

Rising global penetration, lower cost



	2013	2015	2020	2030	2040	2050
New Policies Scenario						
IEA demand projection	3%	4%	7%	11%	14%	18%
Energy Efficiency demand projection	3%	4%	7%	12%	16%	20%
450 Scenario						
IEA demand projection	3%	4%	7%	13%	17%	22%
Energy Efficiency demand projection	3%	4%	7%	14%	19%	25%
Moderate Scenario						
IEA demand projection	3%	4%	8%	14%	20%	25%
Energy Efficiency demand projection	3%	4%	9%	16%	22%	28%
Advanced Scenario						
IEA demand projection	3%	4%	9%	18%	26%	36%
Energy Efficiency demand projection	3%	4%	9%	20%	29%	41%

Source: Global Wind Energy Outlook 2016, GWEC, 2016

In that case, wind generation would cover up to 20% of global power generation, saving more than 3.3 GtCO2/year by 2030.

The GWEC report has much more to offer including wind's contribution to lowering global CO2 emissions, employment potential, investment figures and much more. The numbers are short of amazing and keep getting bigger, depending on the scenario assumed.

One thing, however, is clear and that is the fact that the size of the towers, turbine blades and machinery, not to mention the cranes needed to assemble the ever-bigger blades on top of the ever-taller towers, is getting bigger by leaps and bounds. Wind turbines now come in 6 MW size, and it is no longer big news. The next chapter is offshore wind, which is already big in some places.

Getting bigger over time

Source: Global Wind Energy Outlook 2016, GWEC, 2016

In all GWEC's scenarios, **China** is expected to dominate the wind market, with 31% of total capacities in 2030 in the New Policies and 450 scenarios and 34% in the Moderate and Advanced Scenarios. The EU's share would range between 21% and 28% by 2030, followed by **North America** (20-22%) and **India** (8-11%). ■

Wind Technologies Report
GWEC

Energy Efficiency: The Neglected Low Hanging Fruit

Despite growing interest, energy efficiency remains under-appreciated

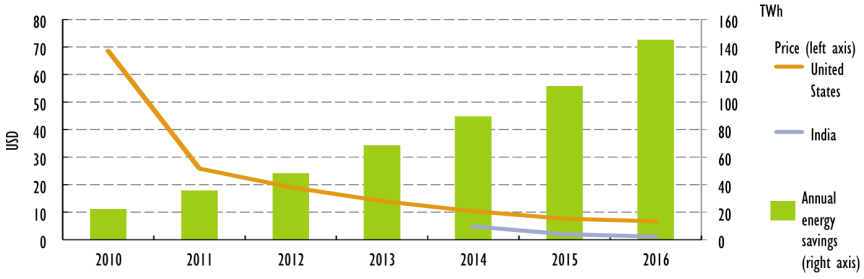
In October 2016, the **International Energy Agency** (IEA) released a new report on **energy efficiency**, which suggests – among other things – that global investment in energy efficiency is not only already huge but growing rapidly, and not just in developed economies. Despite the promising prospects, however, the IEA says far more needs to be done to address climate change.

The IEA's **Energy Efficiency Market Report 2016**, released in mid October found that global investment in energy efficiency in 2015 was a staggering $290 billion and is growing at a remarkable rate.

The IEA, originally focused exclusively on oil and energy security issues, has gradually expanded its focus to include renewables and energy efficiency to address climate change, as further described in this month's accompanying article.

In emphasizing the growing importance of energy efficiency for tackling climate change, **Fatih Birol**, the Executive Director of the IEA, said that energy efficiency is the "single largest action" to help decarbonize the global energy supply system.

Energy efficiency: The low hanging fruit

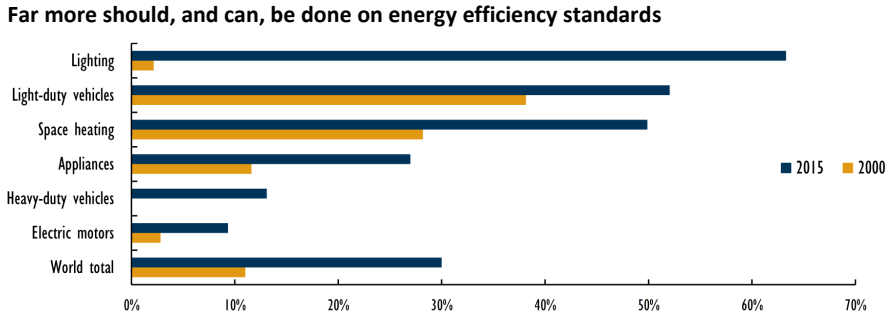


Source: Global Wind Energy Outlook 2016, GWEC, 2016

Global **energy productivity** – i.e., units of energy per unit of GDP – improved 1.8% in 2015, which is triple the annual rate of 0.6% in the 2000s. However, this is still well short of the 2.6% rate of annual improvement that the IEA believes would be required to deliver on the world's climate goals.

Another interesting factoid is that in 2015 improvements in energy efficiency met *more* of the world's energy needs than *new generation*. Even more significantly, global investment in energy efficiency was 66% higher than conventional generation. And this happening at a time of depressed oil prices makes it even more significant.

Echoing **Amory Lovins'** mantra for the past 4 decades, the IEA report says that energy efficiency is an enormous yet poorly understood and under-appreciated business opportunity, and not only for developed economies.



Source: Global Wind Energy Outlook 2016, GWEC, 2016

China alone invested $485 billion in energy efficiency between 2006 and 2014, delivering as much 'energy' as China's investment in renewable energy. China is also the largest global market for specialist 'energy service companies', which have seen rapid growth in the last decade. The significance of moving China on a more efficient and sustainable energy path were described in **Reinventing Fire: China** in the November 2016 issue of this newsletter.

While energy efficiency makes good business sense, distortions in markets for energy, buildings and appliances prevent us from tapping its full potential – parts of the IEA report read like Amory Lovins covered in the November issue of ***EEnergy Informer***.

The IEA's recommendations include the usual suspects:

- Mandatory appliance energy efficiency standards;
- Stringent buildings codes; and
- Minimum mileage standards for vehicles.

While governments have taken significant steps in the right direction – roughly 30% of world's energy consumption is already covered by mandatory standards (Figure above) – far more needs to be done, according to the IEA.

Heating, cooling, ventilating and lighting buildings consumes an enormous amount of energy, which explains why building codes and standards are a must, especially in developing economies where large numbers of new buildings are going to be added in the next decade. Appliances use lots of energy within buildings, which is why appliance energy efficiency matters. Same is true for car mileage standards.

The recipe for saving energy is well-established, as are the means of delivery if there is the will.

A good place to start, of course, would be to remove price subsidies for petroleum products, which leads to wasted energy, rather than energy efficiency. ■

IEA

Distributed Solar Incentives: Too Much Or Not Enough?

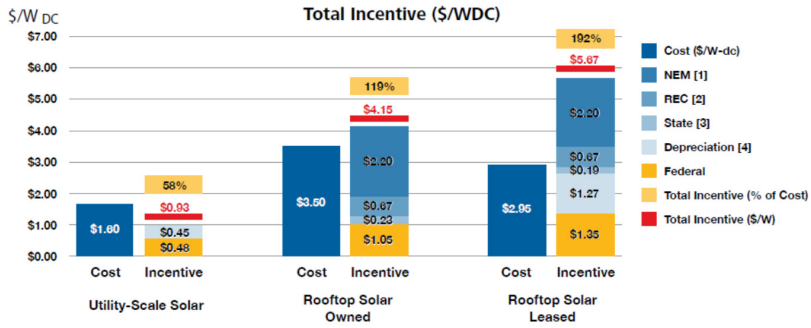
No amount of analysis is going to take the politics out of the economics of distributed solar

The debate on the costs and merits of distributed solar PVs is nothing new to this newsletter's readers. Everyone knows that there is a range of incentives to encourage their uptake in many but not all markets, some more generous than others. In the case of the US, many states have **net energy metering** (NEM) laws, which require the local utility to buy all excess generation from customers with solar PVs and offer a credit equal to prevailing **retail tariffs**. This, more than anything, has been driving the growth of distributed solar.

The popularity of **solar leasing**, which offers customers the option to gain many of the benefits of solar ownership without the upfront capital investment, has been another major reason for the rapid uptake of solar PVs.

Total incentives

Total Incentives Available for a 3.9 kW-dc Customer-Owned and -Leased Solar PV Facilities and an Equivalent Amount of Utility-scale Solar PV Capacity ($/W-dc)



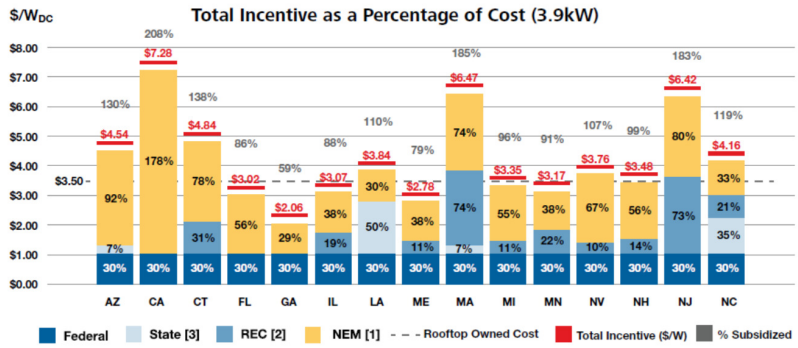
Source: Incentivizing solar energy: An in depth analysis of US solar incentives, prepared for Consumer Energy Alliance's (CEA) by Borlick Associates, LLC

The question, in this context, is – in balance – are rooftop solar PVs good or evil? Do they benefit *all* consumers, including the non-solar ones, or are they a form of regressive subsidy from the not-so-affluent non-solar customers to the more affluent solar customers? These are among the thorny questions that have been debated for some time, and not just in the US.

A recent report by the **Consumer Energy Alliance** (CEA) titled **Incentivizing solar energy: An in depth analysis of US solar incentives**, provides a comprehensive quantification of solar incentives available in 15 states across the US and their impact on non-solar customers. It includes the federal, state, and local incentives available for rooftop solar photovoltaic (PV).

Incentives as percent of cost

Incentives Available for Customer-Owned Residential Solar PV in Selected States, as a Percentage of Installed Cost (3.9kW)



Source: Incentivizing solar energy: An in depth analysis of US solar incentives, prepared for Consumer Energy Alliance's (CEA) by Borlick Associates, LLC

The report analyzes the incentives for solar in **Arizona, California, Connecticut, Florida, Georgia, Illinois, Louisiana, Maine, Massachusetts, Michigan, Minnesota, Nevada, New Hampshire, New Jersey**, and **North Carolina**, relying on publicly available data. It claims to follow "… a conservative approach to quantify the most common incentives for solar energy." Take that as a sign that **Robert Borlick**, the author of the report, is not particularly fond of the prevailing solar PV subsidies or NEM regulation.

The report's key findings include the following:

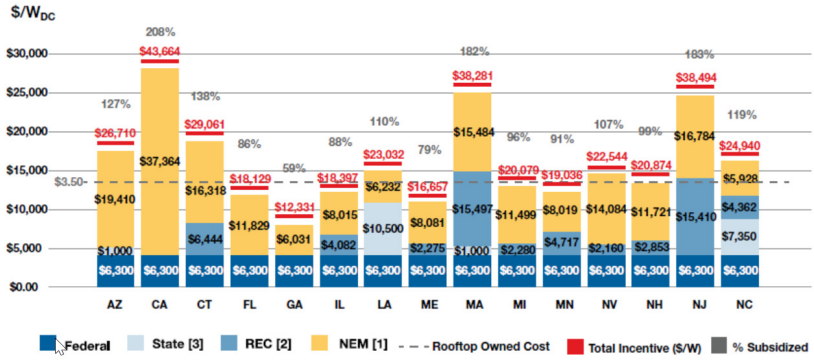
- Existing incentives for residential solar PV are significant and vary widely among the states;
- Third party-owned solar PVs receive significant (additional) incentives;
- Existing incentives will impact the economics of future solar investments; and
- The NEM incentive shifts costs to less affluent non-solar customers.

The report concludes that combining government incentives, such as the solar **investment tax credit** (ITC) with utility incentives, such as those offered under NEM regulations, have reduced residential customers' net costs of installing rooftop solar systems to record-low levels.

The report adds that the combination of all available incentives "are now so significant that, in many states, total incentives are greater than a solar system's total costs," which explains why "… many states are re-examining the scope and methods surrounding their incentive programs … "

Total incentives

Total Incentive ($) for Typical Rooftop Owned System (6.0kW)



Source: Incentivizing solar energy: An in depth analysis of US solar incentives, prepared for Consumer Energy Alliance's (CEA) by Borlick Associates, LLC

Commenting on the report, **Michael Whatley**, Executive Vice President of CEA, said, "As the technology continues to advance, solar energy is becoming an even more incredibly powerful and cost-competitive technology that has the potential to change the face of American energy both today and in the future," adding, "Solar brings with it tremendous benefits for all consumers. Solar's deployment has been truly remarkable as growth rates have exceeded 40% a year for the past 5 years."

Whatley added: " … we hope that CEA's new report will help yield pro-solar, pro-grid and pro-consumer policies to ensure the proliferation of solar technology … for all American consumers." That may be easier said than done as the interests of these groups are radically divergent. It is like saying we want a tax system that taxpayers and welfare recipients equally like. Nice try.

This report, like many others before it, is unlikely to put an end to the solar PV incentive debate. The issues are politically charged, and no amount of analysis is going to take the politics out of the economics of solar PV subsidies. Moreover, as others doing similar studies have concluded, the results crucially depend on who is generating the *extra* kWhs and when and where they are injected into the distribution network. Solar PVs can be good, evil or anything in between depending on the specifics. Solar PV subsidies can be characterized as necessary, generous or inadequate.

And beyond that, some solar advocates argue that the end may justify the means.

Think of **Airbus**, now successfully competing with **Boeing** in civil aviation business on a global scale. There would certainly no Airbus if it were not for the initial subsidies. One can argue that if it were not for Airbus, Boeing's virtual monopoly would cost airline passengers far more than the Airbus subsidies. The arguments about the merits of solar PV subsidies and incentives may be judged in the same context, some day. ■

Incentivizing solar energy

Electricity Too Cheap To Meter: Version 2.0

Creative destruction demands fundamental change in utility sector

In July 2016, **Citi Global Perspectives & Solutions** (GPS) released ***Disruptive Innovations IV: Ten More things to stop and think about***. Energy is first on the list of 10 disruptive things to think about. Not just any kind of energy, but big data disruption in energy. The 10 topics are a fascinating read, including topics that have little to do with energy.

Since the **2008 Global Financial Crisis**, there has been a rise in start-ups concentrating on what Citi calls **Financial Technology** or **FinTech;** add it to your vocabulary next to **HiTech** and **GreenTech**. "Like other disrupters from Silicon Valley – think **AirBnB** or **Uber** – FinTech companies are growing extremely fast. California, the U.K., and New York are the three largest markets for start-up FinTech companies," Citi claims.

Lots of **venture capital** (VC) and thousands of smart, highly paid and highly motivated people are engaged in the FinTech sector. With so much money and talent, you would expect something will come out of the sector. But what?

Add to your vocabulary: FinTech and where you can find them

Place	Market size (Billion £)	FinTech Staff
California	4.7	74,000
UK	6.6	61,000
New York	5.6	57,000
Germany	1.8	13,000
Hong Kong	0.6	8,000
Singapore	0.6	7,000
Australia	0.7	10,000

Source: Disruptive Innovations IV: Ten More things to stop and think about, Citi Global Perspectives & Solutions, July 2016

In the electricity and utility space, Citi says,

> "The democratization of energy could see **renewables** and **distributed energy resources** (DERs) proliferate at the local level meaning fewer new power plants would be needed due to **demand-side management** and optimal capacity utilization of power plants. Consumers could eventually "**trade" energy with others in the form of "transactive energy**." Utilities are already developing ways to value DERs at the neighborhood level and the **value of electricity would differ depending on locations** and usage to value ancillary services. The ability to collect, process, and analyze more data for optimization and automation is key to these developments."

Not entirely new, but Citi's report reinforces what we already know.

> "Utilities, for example, would become **distribution service platform providers** for DERs, as the **State of New York** is already envisioning. Technology companies could provide energy network optimizing software or even operate platforms and energy companies that transition to providing services could become asset-light, as they could control how energy is routed and optimized. Third-parties or homeowners would become energy providers through DERs and auto companies would become service and energy providers."

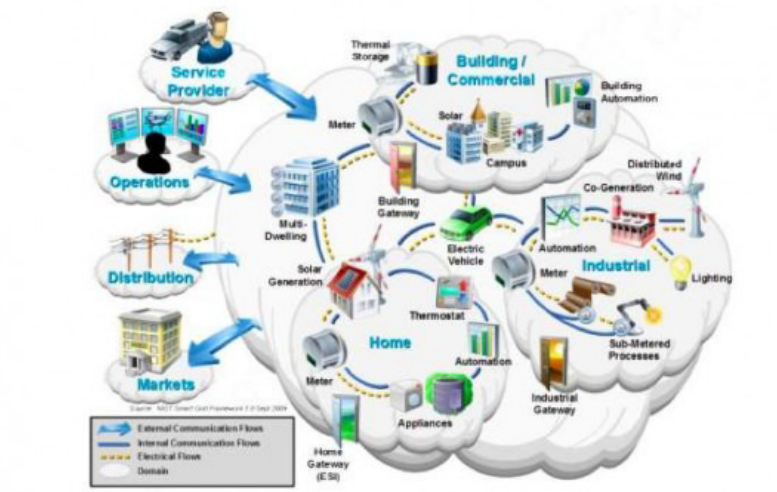
As others have already predicted, Citi sees a future where the *commodity* price of electricity could be approaching zero:

> " …. As new builds in the power sector involve more **near zero-variable cost sources**, such as wind and solar, along with greater demand and storage optimization, the goal of dramatically lowering energy costs for all, with the possibility of **free energy** in some corners, may finally come to fruition. …"

That, of course, was what was envisioned at the dawn of the **nuclear age**, with the promise that nuclear energy would be **too cheap to meter** – the reality, as we know, turned out rather differently. But perhaps

the version 2.0 will deliver essentially free electrons some day. We still have to pay for the delivery and the distribution network and for balancing supply and demand in real-time.

Figure 9. Future Grid Systems and Smart Building Can Communicate in Ways that Improve Overall System Efficiency and Reliability



Source: U.S. Department of Energy, National Institute of Standards and Technology

Another promising development, Citi agrees, is the rise of so-called **virtual power plants** (VPPs) described in Aug 2016 issue of this newsletter:

"**Virtual power plants** can become a reality by using software to integrate distributed generating resources (DERs), energy storage, and demand response resources from different locations together as if it is a single power plant."

Citi, like everyone else looking at such issues, recognizes that **policy** and **regulations** are, and will continue to be, key drives in the utility space, no matter what happens to technology or costs.

Citi highlights regulatory reform proceedings in New York:

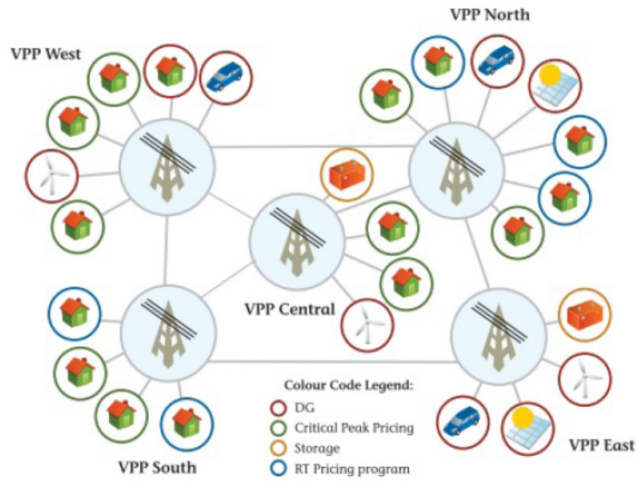
> "New York's **Reforming the Energy Vision**, or REV, is one of the most ambitious regulations put forth by a regulatory agency in changing the business models of utilities. Regulators foresee that utilities would become **Distribution Service Platform (DSP) providers** that operate a DER marketplace, deploy DERs optimally, and generate revenue from DER origination, as well as system integration and operation. In the distributed, decentralized world, particularly in the electricity space where the supply and demand of electricity must match instantly, ensuring a smooth and optimal operation of the grid necessarily requires advanced analytics to process the vast amount of data generated."

What happens to the incumbent utilities in this environment? According to Citi:

> "The **big data revolution** means energy companies could increasingly become **asset-light**. Numerous companies providing software or services thrive online, building on the physical infrastructure that firms construct. As utilities in the future increasingly serve as platform providers, once they have created efficiency in and have control over the distribution of electricity, they could divest some of their physical assets."

And like others, Citi is big on **platforms** that allow **peer-to-peer trading** and **transactive energy**:

How Distributed Energy Resources Become Virtual Power Plants



Source: Disruptive Innovations IV, Citi GPS, July 2016

> "In a **transactive energy** world, having the right platform, like what **eBay** or **Alibaba** has built, could be extraordinarily lucrative, especially as the network effect increases when the platform contains more and more customers."

Commenting on the future of utilities, Citi says, "…. utilities could be winners but only if they transform with the times," adding,

> "This is a story of how software will transform a hardware-dominated sector; it is the kind of creative destruction that demands fundamental changes in an entire sector."

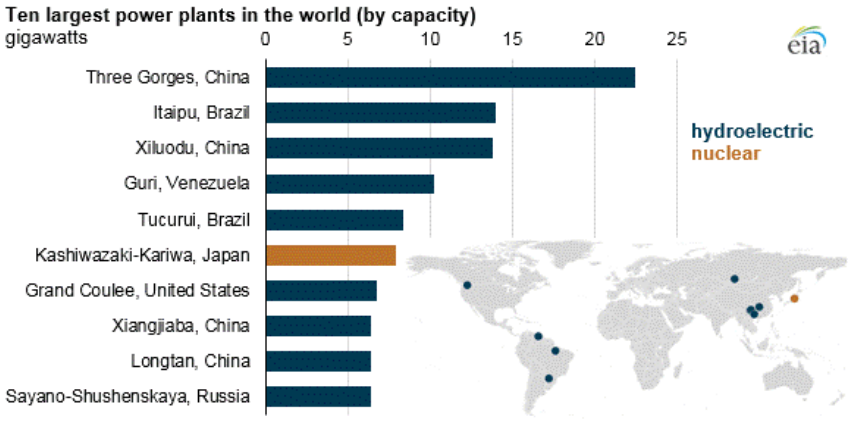
While wordy and not necessarily containing anything new or novel, the Citi's report is nevertheless worth a read, and not just on the energy topics but in 9 other equally disruptive forces at play in other sectors of the economy. ■

Disruptive Innovations

Word's Largest Power Plants

Mostly hydro and mostly over there

According to the **Energy Information Administration** (EIA), in 2015, there were 62,500 power plants with 6,000 GW of capacity operating around the world. Nine of the largest 10 are hydroelectric, 4 of the largest are in China. The world's largest dam, **Three Gorges** on the Yangtze River has a capacity of 22.5 GW followed by **Itaipu**, on Brazil's border. Hydroelectric power is the second-largest source of electricity in China, after coal, accounting for 20% of the country's total generation in 2015.



Source: U.S. Energy Information Administration

Japan's massive **Kashiwazaki-Kariwa nuclear facility**, the largest nuclear plant in the world, has not operated since being shut down following the Fukushima accident in 2011 and its fate remains unclear. It is included on the list just in case. ■

Book Review: *Energy, Complexity and Wealth Maximization*

By Robert Ayres, Springer, 2016, 587 pages

As suggested by its title, this is not the kind of book you would take to the beach or are likely to hear discussed at cocktail parties – unless you hang around highly sophisticated people. In the book's Preface, the author, **Robert Ayres**, an emeritus Professor at **INSEAD**, Fontainebleau, France – who has authored and co-authored 22 volumes over a long and distinguished career, says the book has had "a long gestation." Ayres apparently began thinking about the topic starting in 1994, after publishing another volume titled **Information, Entropy, and Progress**, "an attempt to

explain evolution in terms of accumulation of 'useful information', as distinguished from just information."

The current volume, which is – among other things – about the "proper role of energy in economic science" – is expansive covering basic laws of physics and how energy and complexity lead to wealth maximization. It may come across as overwhelming at first, given the sheer volume of knowledge that Ayres has managed to fit into the book and the many topics he endeavors to cover, explain, and integrate. But rest assured, the book has an easy style that anyone with basic command of economics and some understanding of laws of physics should be able to handle.

Ayres' choice of covering energy, complexity and wealth maximization in a single volume – albeit a big one – may also seem odd at first. But here again, a careful reading of the book's excellent Preface should clarify why. He lucidly describes wealth and its relevance in ways this reviewer had not contemplated until now. Ayres explains, "the more choices you have, the greater your wealth" and observes, "increasing wealth is a consequence of information flow." The book's title is quite appropriate; the book covers economic theory, energy flow, economic growth, and wealth accumulation, more or less in that order.

If you are patient to make it through, a big if, you are likely to see the connections between energy, complexity and wealth – and that alone should make this book worth a read.

To say that Ayres has read a lot and is attempting to share what he has learned in the process is an understatement. He covers philosophy, quantum physics, thermodynamics, relativity, biological evolution, geology, earth science, entropy, exergy, astronomy, astrophysics, black holes plus history of the universe from the Big Bang to present. He describes the physical universe, ocean currents, atmospheric circulation and climate change. Next is energy and technology, human evolution, population, energy forms. The list of topics covered, like the book itself, is long. By the time you get to chapter 12, Ayres describes the circular economy and the limits to growth – among other things.

The book ends with a massive glossary, a long list of "people" whose work is mentioned in the volume followed by a massive bibliography that only someone like Ayres has the time to read.

The magic of the book, however, is that the patient reader is ultimately handsomely rewarded as Ayres manages to connect a host of seemingly unrelated topics while drawing useful conclusions and insights that are hard to match. Energy and wealth maximization are connected thru complexity – that is the bottom line. As Ayres explains, the underlying physical theory, the universe doing work as it cools and expands, leads to complexity.

The best reason to read this book is that you can skip reading numerous others. ■

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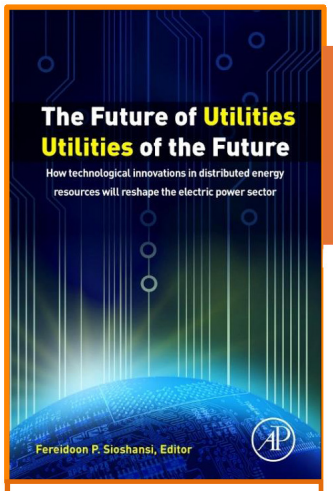

Future of Utilities - Utilities of the Future

How technological innovations in distributed generation will reshape the electric power sector

Edited by: ***Fereidoon P. Sioshansi***, President, Menlo Energy Economics, San Francisco, CA, USA

Rapid technological advancements plus falling costs of **distributed energy resources** (DERs) – which includes **energy efficiency** improvements plus **distributed generation** – is turning an increasing number of **consumers** into ***prosumers***, eroding utility revenues and threatening the historical business model.

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