ELECTRIC SLIDE

Transitioning to a Low-Carbon Future

THIS SERIES

In three articles over 2016-2017, Walden Asset Management shares its perspective on what transitioning to a low-carbon future means for one critical area of the US economy: *electricity generation*. Part 1 presents today's US electricity landscape. Part 2 discusses how low-carbon electricity is being financed and the role of policy and regulation. Part 3 analyzes some of the investment implications of this transition. This series stems from discussions at our Investment Committee and represents a collaborative effort between the fundamental and environmental, social, and governance (ESG) research teams at Walden.

PART 1: ELECTRICITY LANDSCAPE

INTRODUCTION

More competitive pricing as well as public policy in support of lower-carbon fuel sources are slowly transforming electricity generation in the US. Yet technical hurdles need to be overcome in order to accelerate the pace of change necessary to meet global goals on climate change.

THE LOW-CARBON IMPERATIVE

On April 22, 2016 representatives from 175 countries met at the United Nations headquarters in New York to sign the Paris Climate agreement. The goal of the agreement is to limit the increase in the global average temperature to below 2°C above pre-industrial levels, and pursue efforts to limit the temperature increase to 1.5°C. Walden strongly supports this goal and applauds the leaders of companies, countries, and civil society organizations that helped bring about this historic agreement.

To meet the goal of limiting warming to not more than 1.5° C, analysts estimate it will be necessary for global energy and industry CO_2 emissions to decline to zero around 2050.[1] Each country that has signed the Paris Agreement has developed its own goals. The US has committed to cut greenhouse gas (GHG) emissions by 26-28% from 2005 levels by 2025. This target requires changes to energy demand patterns and sources of energy supply — which are already underway — and will impact the value of many companies in which we invest client assets. Roughly one-third of US GHG emissions comes from the generation of electricity[2], so reducing the carbon footprint of the electricity grid will be essential to meet the US's climate commitment.

Using a framework of zero CO_2 emissions by 2050, below we discuss the current sources of supply of utility-scale electricity generation. We highlight the transition already taking place in the electricity grid: from a generation fleet powered predominantly by coal-fired power plants to one where natural gas plays an equally important role, and illustrate the significant growth in generation and installed capacity of renewable power. Declines in the costs of renewable electricity over the past several years have made renewables more competitive than ever, but obstacles to broader adoption remain, and we address those as well.

It is also important to note that electricity demand has been flat for roughly a decade, decoupling from the US economy, which has grown following the Great Recession. The challenge to reach zero CO_2 emissions will require addressing both the demand and supply side of the power equation.

OVERVIEW OF US POWER SUPPLY AND DEMAND

While the amount of electricity produced from burning coal has been in steady decline since the mid-1990s, it had consistently accounted for a greater share of electricity generation than any other fuel source until last year. In 2015 coal and natural gas fueled essentially identical amounts of US electricity generation (See Figures 1a and 1b).

Electricity generation from renewables has taken up some of the falling output from coal. Declining costs of renewables, and policies and subsidies — including generous tax incentives for investment and production — designed to support growth of renewables (and raise the cost of conventional carbon-emitting sources) have made them more competitive (discussed below). Still, by 2015 only 14% of power generation came from renewable sources. Of that amount, almost 50% came from hydroelectric sources, a controversial form of renewable power. While wind and solar sources have grown rapidly in the ten years to 2015 at compound annual growth rates of 27% and 47%, respectively, their share of electricity generation remains small. Wind accounts for 5% of electricity generation by kilowatt-hours, seven times the contribution from solar[3] (see Figures 1a and 1b).

Most electricity previously generated by coal-fired sources has been assumed by gas-fired power plants, which in 2015 accounted for approximately one-third of all US generation, up from less than 20% as recently as 2004. The increasing US-based supply and decreasing cost of natural gas as well as its lower emissions, including CO_2 footprint, compared with coal, has made it increasingly attractive for power producers. But while gas-fired generation has been growing at 6% annually in an electricity market that has otherwise been flat for ten years, its growth pales in comparison to that of wind and solar. For environmentally attractive alternatives, opportunities for substantial share gains remain.

As referenced above, the aforementioned shifts in underlying sources of supply have occurred amid a

Figure 1a: US Electricity Generation by Fuel, 2015

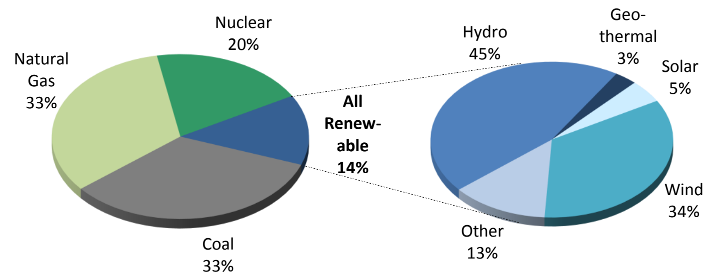
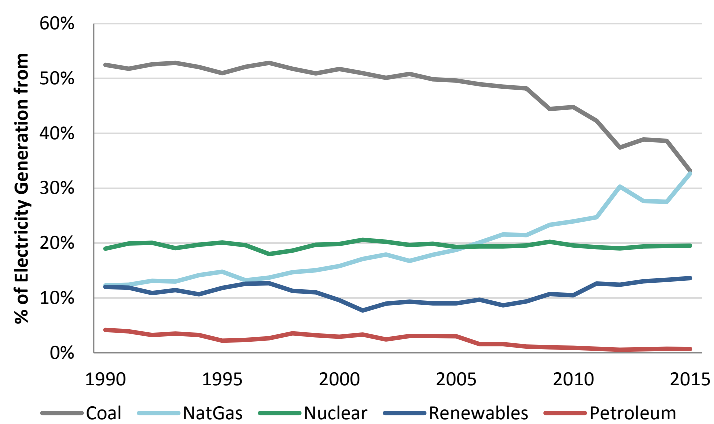


Figure 1b: US Electricity Generation by Fuel, 1990-2015



flattening demand curve for electricity. From 1950 through 2007, US electricity demand grew at a rate of approximately 65% of nominal US GDP growth, or about 4.5% annually. However, since peaking in 2007, total US net electricity generation has declined at a 0.2% annual rate, while US nominal GDP has grown at a 2.9% annual rate. Decoupling electricity demand from economic growth will continue to be an important and cost-effective contributor to reducing overall emissions. By most estimates energy efficiency programs are currently cheaper to implement on a per kilowatt-hour basis than any of the new renewable supply sources.

GENERATION VS. CAPACITY

Differences between supply capacity and generation highlight deeper underlying changes. Essentially "name plate capacity" defines how much power an individual generating unit (coal plant, solar array, dam, wind farm, combined cycle gas turbine) can produce; whereas actual generation measures how much power a unit does produce. The ratio of generation to capacity is referred to as the "capacity factor" and known as utilization or uptime.

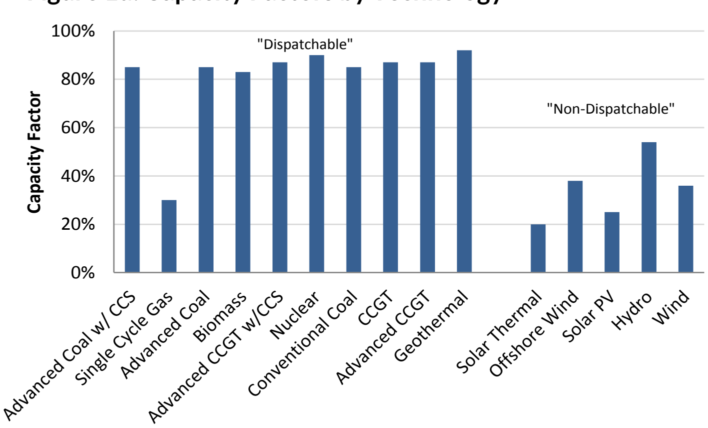
Many variables influence capacity factors, including weather conditions, variable operating cost, marginal demand, and downtime required for refueling or maintenance. In simple terms, a solar plant has a lower capacity factor than other generation options since the sun does not always shine. On the other hand, coal and nuclear plants are designed to run as much as possible except for maintenance (which is usually planned around lulls in demand), and as a result have much higher capacity factors.

Analyzing the power generation industry in terms of installed capacity shows a more accelerated shift to renewables. As of 2015, only 27% of generating capacity came from coal sources, a decline of 2.6% annually since 2011, or a net reduction in capacity of 32 Gigawatts. That is enough capacity to power 19 million homes for a year.

Figure 1c: US Electricity Capacity & Generation

Fuel	2015 % of Generation	2015 % of Capacity	*10 Year CAGR to 2015E* Generation	*10 Year CAGR to 2015E* Capacity
Coal	33.2%	26.7%	-3.9%	-0.9%
Natural Gas	32.7%	40.5%	5.8%	1.3%
Nuclear	19.5%	9.3%	0.2%	0.0%
All Renewables	14.0%	16.2%	4.8%	5.6%
Hydroelectric	*6.1%*	*7.5%*	*-0.7%*	*0.3%*
Solar	*0.6%*	*1.3%*	*47.3%*	*42.1%*
Wind	*4.7%*	*7.0%*	*26.8%*	*24.0%*
Other Renewable	*2.6%*	*0.4%*	n/a	n/a
Other	0.7%	7.3%	n/a	n/a
Total	**100.0%**	**100.0%**	**0.1%**	**0.9%**

Figure 1d: Capacity Factors by Technology



Natural gas accounts for 40% of capacity, but has been growing at only ~1% annually over the short and longer term. Renewables as of 2015 accounted for 16% of generating capacity and have been growing at 7-8% annually, led by wind and solar, which have grown at 24% and 42% annually over the past ten years. Since 2011 solar generating capacity has accelerated to nearly 75% annual growth.

Figure 1c provides a summary of share of electricity generation by fuel in 2015, as well as growth rates of generation and installed capacity.

OPPORTUNITIES AND CHALLENGES FOR GROWTH OF RENEWABLES

A key opportunity for renewables is their position on what is known as the power dispatch curve (essentially the supply curve). After initial construction, renewables have virtually zero variable operating costs and are one of several "baseload" sources of generation. Once they are in operation the optimal utilization is the maximum allowed by the capacity factors; in other words, they would ideally run all the time. On the basis of variable cost, wind and solar are even more attractive than other low carbon baseload sources of power generation such as hydro and nuclear. But all of these sources have relatively low or no variable operating costs compared to their initial fixed costs.

However, renewables face two challenges to greater adoption in comparison with other baseload sources. The first is that they have lower capacity factors, as described above (see Figure 1d). Solar has an average capacity factor of 20-25%, wind 30-40%. Coal, however, has a capacity factor of 60-80%, and nuclear plants have capacity factors of greater than 90%, running almost continuously except for refueling outages. This is a challenge because power generators and utilities rely on baseload sources to supply the minimum electricity needed on any given day. For efficiency and grid stabilization, it helps for baseload sources to operate at high utilization and according to a known operating schedule.

The second challenge for renewables is "dispatchability," or the ability to turn them on and off as needed to follow demand. Most baseload sources are not readily dispatchable, including renewables. Coal and nuclear plants take hours or even days to get to full operation; solar and wind are dependent on underlying weather conditions. This makes all of them poor sources of supply to respond to spikes in demand (a hot summer day, for example). Gas-fired plants, in contrast, can be switched on quickly and can run at full capacity almost in minutes, making them excellent sources of supply to meet "peaking" demand.

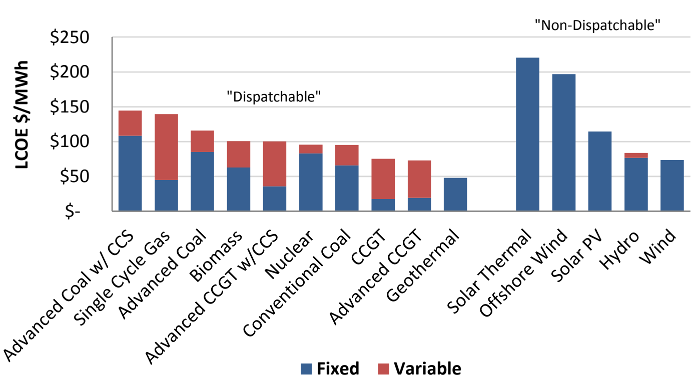
However, relative to most renewables, operators of other baseload sources can generally plan in advance for known outages (for maintenance, refueling, etc.) and schedule them during seasonal periods of lower demand. Despite solar's output being naturally aligned with daily electricity needs, renewables are generally less reliable than other baseload sources in meeting average electricity demand.

A COST COMPARISON: LEVELIZED COST OF ENERGY

The rapid increase in renewable power generation capacity over the last decade, as well as the increased share of natural gas in electricity generation, is in large part due to falling costs of production. This price decline has been driven by: technological breakthroughs such as hydraulic fracturing; fundamental laws of supply and demand (i.e., glut of natural gas and solar panels); and policy decisions (investment and production tax credits). Nonetheless, renewables remain more expensive than conventional sources, and in particular gas-fired generation.

Straightforward cost comparisons of different electricity generation technologies are difficult. In order to attempt to make apples-to-apples comparisons, the standard approach is to compare the "levelized cost of energy" (LCOE) from different sources. The LCOE includes capital costs, fixed and variable operations and maintenance costs, as well as the implicit cost of carbon and subsidies where relevant. While helpful, estimates based on this approach should be viewed cautiously since they depend upon many assumptions.

Figure 1e: Fixed, Variable & Levelized Cost of Power



For example, a critical assumption relates to the capacity factor used for different technologies. Complicating the analysis further is significant variability in capacity factors for similar technologies (e.g., solar) deployed in different regions of the US (i.e., Southwest vs. New England). Figure 1e shows the estimated LCOE on a $/MWh basis for plants anticipated to be in service in 2020. Onshore wind, hydro, and solar photovoltaics are now cost competitive on an LCOE basis with fossil fuel and nuclear technologies, although they still have the disadvantage of being non-dispatchable. Conversely, offshore wind and solar thermal remain relatively expensive.

To demonstrate the pace of cost declines, compare these estimates to those made by the EIA in 2010. That year, the EIA estimated the cost of wind to enter service in 2016 would be $149/MWh compared to $74/MWh estimated in 2015, a reduction of 50%. Similarly, solar photovoltaics entering service in 2016 were estimated to cost $396/MWh compared to a current estimate of $114/MWh, a decline of 71%.

CONCLUSION

The transition to a low-carbon future is underway. Natural gas plants—a bridge technology to a still cleaner generation footprint—have assumed some of baseload capacity that heretofore has been served by coal plants. How does this translate into the US GHG reduction goals? According to the US EPA, GHG emissions in 2014 were 9% below 2005 levels. In 2005, energy-related CO_2 emissions were 5.9 billion metric tons. In 2014, CO_2 emissions were 5.4 billion metric tons, also representing approximately a 9% decrease over the decade.[4]

The challenge to greater adoption of renewables is significant, yet will be imperative to meet the goal of reducing emissions 26-28% by 2025. Still, as technology has improved and costs have declined, wind, solar, and other sources of electricity generation have become increasingly competitive with traditional sources.

PART 2: FINANCING RENEWABLES

INTRODUCTION

In Part 2 of this series, we provide a survey of how renewable energy is currently being financed and who is involved. We describe some of the public policy tools utilized by regulators and elected officials, including tax subsidies, policy mandates, and regulations. We discuss examples of direct public financing provided by the government, such as research and development and loan guarantees, and we highlight examples of private investment responding to the incentives in place. Yet the rapid pace of change in technology and public policy could mean that, in some instances, our analysis may have a short shelf life!

THE LOW-CARBON IMPERATIVE

The International Energy Agency estimated in 2015 that $13.5 trillion in energy efficiency and low-carbon technology investment is necessary by 2030 to meet pledges made by countries to reduce emissions.[1] That is $840 billion per year; and yet in 2015 global clean energy investment totaled just $348 billion[2], with $44 billion invested in the United States.[3] While the improving economics of renewable technology has enhanced the business case for investment and private capital is available, the scale of investment required means that government policy, incentives, and direct investment must continue to play a central role to help us achieve a low-carbon future.

Among the more aggressive private investors in renewable generation is Berkshire Hathaway, Inc.[4] In June 2014, Chairman and CEO Warren Buffett told those assembled at the Edison Electric Institute annual conference that Berkshire's utility subsidiary, Berkshire Hathaway Energy (BHE), was prepared to invest another $15 billion in renewable power developments, on top of $15 billion already committed. Most of the money has been invested by MidAmerican Energy, Berkshire's regulated utility subsidiary, which serves parts of Iowa, Illinois, South Dakota, and Nebraska. MidAmerican and Iowa offer instructive case studies in the accelerating shift from conventional fossil fuel generation to renewable generation: wind power provided 47 percent of MidAmerican's retail generation in Iowa as of 2015, versus zero as recently as 2004; and management in April 2016 announced plans to move to 100 percent.[5]

Berkshire Hathaway is the largest owner of wind and solar generation in the United States, with 7 and 6 percent of total installed capacity, respectively. However, Mr. Buffett has been clear that most, if not all, of this investment has been predicated on BHE's receiving federal tax credits and other subsidies that make those investments more cost competitive. Buffet has said that incentives are "the only reason to build [wind farms]. They don't make sense without the tax credit."

THE ECONOMICS OF RENEWABLES

BHE is not alone. Other utilities have told Walden that they invest in renewable projects that are outside their regulated asset base for the tax credits available to offset income generated by their highly profitable utility businesses. They judge that the standalone cost of many renewables projects does not currently have an acceptable return profile to justify the risk relative to other ways these companies could choose to allocate capital. According to a utility executive in New England, for example, the average retail price of electricity is approximately $0.15 per kilowatt hour (kWh).[6] Offshore wind power can cost $0.20-$.25/kWh, with essentially all the investment made in up front capital costs.[7] Solar can cost twice as much for utilities to construct (and many times more for residential installation, as we discuss further below).

On the other end of the cost spectrum, however, direct investments in energy efficiency programs approved by utility regulators can cost as little as $0.03/kWh, have much less capital and reputational risk, and may prove as important in shrinking the carbon footprint of the electricity grid as a large scale renewables build-out. Indeed, curbing demand for electricity in general may have greater impact than shifting the sources of supply; however, this article focuses on the later.

Clearly, tax subsidies are an important economic driver of private investor willingness to fund renewables investment, though the beneficiaries of such subsidies are surely more apt to lobby for them based on need rather than merely as a way to enhance their profits. And in fact some estimate the cost of new on-shore wind in New England to be $0.08/kWh, well below the retail rate, though still above the current wholesale rate of electricity in New England of $0.02/kWh.

While anecdotal, these examples indicate that investment in renewable energy continues to rely heavily on government support. This holds true despite the declining costs of renewables thanks to improving technology and economies of scale. For example, according to the US Department of Energy, the cost of wind power has declined by 90 percent since the 1980s; installed capacity has increased exponentially, with likely inter-related cause and effect (see Figure 2a). The development of solar power has followed a similar path.

As we noted in Part 1 of this series, the costs and benefits of renewables are distributed unevenly since certain geographic regions are better suited to wind, solar, and even fossil fuel generation relative to others. Various forms of government support make assessment of true market economics of these investments even more challenging.

Hence, any generalized analysis of the financing of renewables investments will likely prove murky at best. Likewise, companies involved in the extraction of fossil fuels for conventional electricity generation technology also enjoy a variety of subsidies, further complicating a comparison of costs of electricity generation technology.[8]

Given explicit government commitments to move to a lower-carbon economy, this article investigates how the transition in power generation is being financed in the United States.

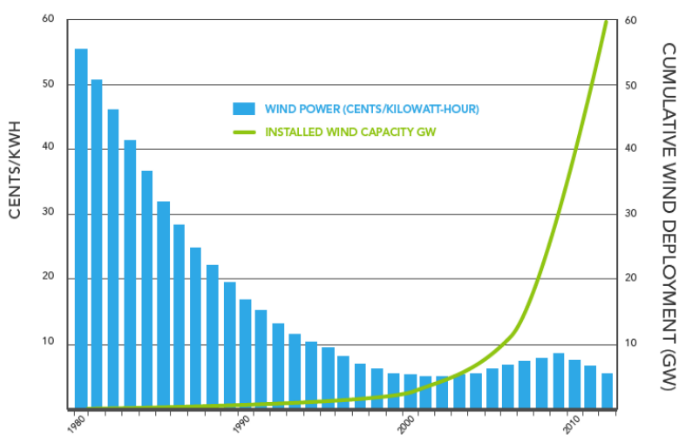
REGULATIONS AND POLICY MANDATES

Legislators and regulators at the state and federal level have enacted a number of measures to mandate the transition to lower-carbon electricity generation. These measures set targets for emissions reductions or renewable electricity generation and require companies to take various steps to comply or face financial penalties.

Renewable Portfolio Standards (RPS)

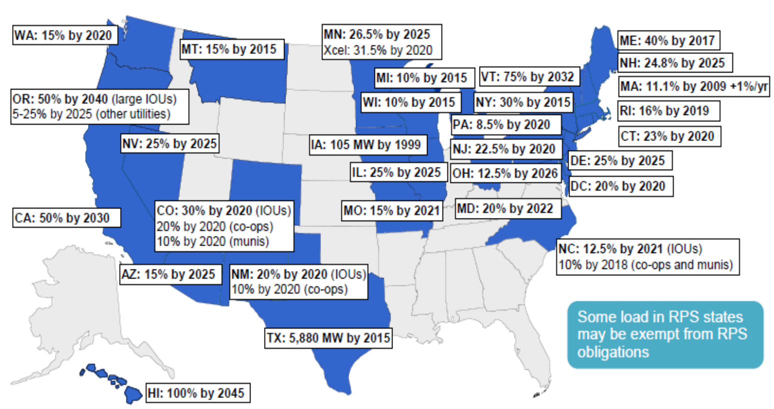
Renewable Portfolio Standards require suppliers of electricity to supply a minimum amount of electricity from eligible sources of renewable energy, and are one of the most common policy tools used to spur development of renewable resources in the United States. Currently, 29 states and the District of Columbia have such standards (see Figure 2b). However, there is no national renewable

Figure 2a: Wind Power Cost and Installed Capacity



Source: Department of Energy

Figure 2b: State Renewable Portfolio Standards



Source: Berkeley Lab

portfolio standard; all RPS to date have been set by the disparate state public utility commissions in response to varying degrees of support from utilities and rate payers. As a result, standards vary widely in terms of how much energy to source from renewables, timeline for compliance, and even what constitutes an eligible fuel source (particularly with regard to hydro).

Net Metering

Numerous states have incentivized residential and commercial solar deployment through net metering laws, which enable customers to sell to the utility at retail prices electricity generated in excess of what is used.[9] Policies vary by state, but, according to the Solar Energy Industries Association, in 2013 some form of net metering was in place in 43 states. While net metering has been important in stimulating demand for distributed generation, the appropriate amount and who pays the subsidy have become the subject of fierce debate in a number of states.

CARBON POLLUTION LIMITS

Various regulators have established specific limits on carbon pollution from electricity generation. In 2013, such a program went into effect in California. The cap-and-trade program sets an aggregate GHG allowance budget (the cap) for covered entities and provides a mechanism for trading allowances. The program applies to electricity generating facilities and importers, among other sources.

The Regional Greenhouse Gas Initiative (RGGI) functions in a similar way, albeit with a narrower scope of emissions generation. RGGI has set carbon dioxide (CO_2) reduction targets for electricity generation in the New England states, New York, Delaware, and Maryland. Since the program was established in 2009, CO_2 emissions in the region have declined more than 20 percent, while coal-fired electricity generation has declined from 18 to 9 percent of total generation. RGGI generates revenue for the participating states through the auctioning of CO_2 allowances. Reportedly, $2.4 billion in proceeds has been generated, a significant portion of which has been used by the states to invest in energy efficiency efforts, which, as noted above, is one of the more cost-effective investments for reducing the climate impact of electricity generation.

The Clean Power Plan (CPP), proposed by the Obama Administration, directly addresses the climate impact of electricity generation. Currently under review in the courts, the CPP provides targets for CO_2 reduction from electricity generation, and covers the bulk of the country.

Other existing regulations have also had the effect of transitioning electricity generation away from higher carbon fuel sources such as coal. For example, the Mercury Air Toxics Standards that require power plants to limit emissions of toxic air pollutants like mercury, arsenic, and metals. The technology required to meet the standards has made coal-fired generation less economic compared to natural gas and renewables.

What has been the impact of these regulations? In the 2016 update of its annual status report on RPS, the Lawrence Berkeley National Laboratory found that 60 percent of all growth in renewable electricity generation and 57 percent of capacity since 2000 is associated with RPS requirements.[10] The report also forecasts total RPS-driven demand will double from 2015 to 2030, which could require an additional 60 gigawatts, roughly a 50 percent increase from current non-hydro renewable capacity. Interestingly, RPS appear to have spurred renewable energy generation even in states without an RPS, with 13 states installing capacity to meet demands of other states. Finally, the report found that compliance costs associated with RPS averaged 1.3 percent of the average retail electricity bill.

Clearly RPS requirements have had an important role in the development of renewables. But if the Berkeley Lab figures are accurate, they imply that nearly half of all the renewable development over the past decade and a half has been driven by other forces. We investigate these further below.

DIRECT INCENTIVES TO THE PRIVATE SECTOR—PUBLIC SECTOR FINANCING OF NEW R&D

Governments also provide capital directly to support technologies that cannot yet compete with incumbent electricity generation. The provision of capital comes in two primary forms: grants for research and development (R&D) and loan guarantees. Public financing addresses a critical gap in helping advance technologies to a stage where private financing (venture capital, bank financing, public debt and equity markets, etc.) can step in. For example, the US Department of Energy's (DOE) Loan Programs Office has provided more than $30 billion in loans, loan guarantees, and commitments over the last decade and has

$40 billion in remaining loan authority. These loans have leveraged more than $50 billion in additional project-level investment.[11]

The US government is also part of Mission Innovation, an initiative that was announced at the United Nations Climate Change Conference in Paris with the stated purpose of accelerating public and private global clean energy innovation to "address global climate change, provide affordable clean energy to consumers, including in the developing world, and create additional commercial opportunities in clean energy." Through the initiative, 20 countries, plus a number of countries represented collectively by the European Union, have committed to double their respective clean energy research and development investment over five years, reaching a total of approximately $30 billion by 2021 (see Figure 2c).[12]

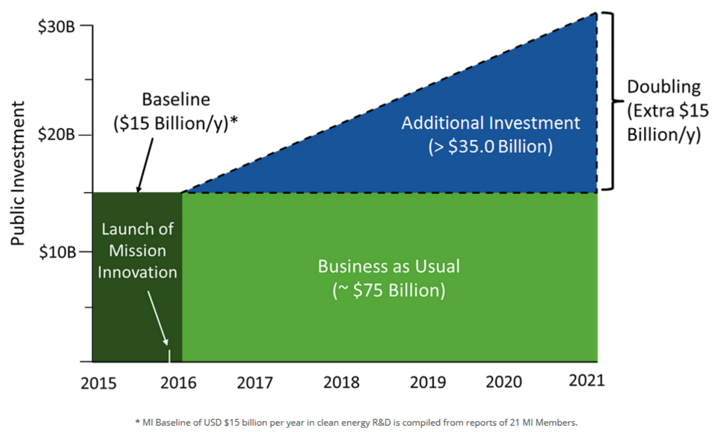
As part of the Mission Innovation effort, the United States has committed to increase funding from $6.4 billion in 2015 to $12.8 billion per year in 2021.[13] The US government focuses its R&D efforts on a variety of technologies and efforts. With a budget of $280 million in 2014 and 2015, the Advanced Research Projects Agency-Energy, part of the DOE, invests in research of "high-potential, high-impact energy technologies that are too early for private-sector investment."[14]

The SunShot Initiative is another example of direct government investment. Launched by the DOE in 2011, the SunShot Initiative's goal is to drive down the cost of solar electricity to $0.06/kWh, without incentives, by the year 2020. Since its inception, the initiative has provided R&D funding for more than 250 projects ranging from research on how to lower the cost of solar panels and other hardware to cutting red tape and improving access to affordable financing. The DOE reports that it has spent approximately $2.3 billion on solar-related R&D, with net economic benefits totaling more than $15 billion.[15] However, as Figure 2d shows, while costs have fallen significantly, in order to meet its 2020 target, prices in all segments (residential, commercial, and utility) still need to decline significantly, by $0.70-$1.10 per watt of installed capacity, or 40 to 50 percent.

DIRECT INCENTIVES TO THE PRIVATE SECTOR—TAX SUBSIDIES

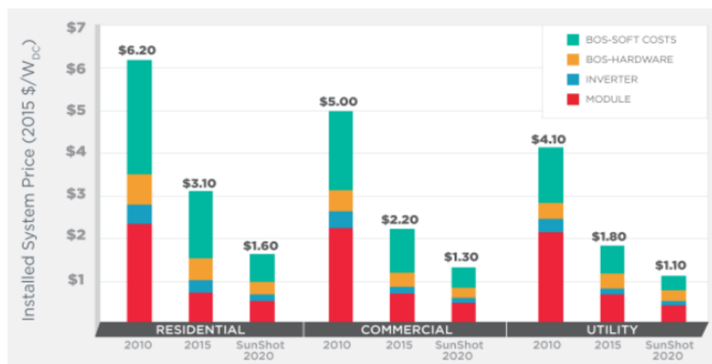
Government policy also provides direct support to the private sector in the form of tax subsidies for renewable investment and generation. Two of the more prominent forms of assistance available are known as the Investment Tax Credit (ITC) and the Production Tax Credit (PTC).

Figure 2c: Clean Energy R&D Investment



Source: Mission Innovation

Figure 2d: Installed PV System Prices



Source: Energy.gov

Established in 2005, the ITC originally targeted residential and commercial solar energy systems (though utilities and other enterprises now participate broadly) and provides up to a 30 percent rebate in the form of a tax credit on the cost of the equipment and installation of a solar-electric system. A typical 10kW residential installation may cost $30,000 (before the rebate), a dramatic reduction from the estimated $60,000 cost of the same system five or six years ago. But the payback period is still long and the price per kW of installed capacity remains high at $3,000.

For example, in New Jersey, which has a well-developed solar program, a solar installation can provide most of a homeowner's annual electricity needs based on average consumption. But even at residential electricity rates of $0.18/kWh and average annual bills of $1,600 (both well above national averages), the payback period is nearly 19 years before the subsidy, or 13 years including it, if electricity prices are stable.

While solar panel prices have declined dramatically as more supply has entered the market, the panel itself represents a small part of the overall cost of a residential solar installation. Using the example above, $30,000 for a 10kW solar installation yields a cost per watt installed of about $3, well above the $0.50 cost/watt (or $5,000) for the panel alone. The fact that such a big portion of the total installed cost goes to labor, materials, and “soft” costs such as permitting suggests that the costs of solar may be moving closer to a natural floor.

A number of commercial investors have emerged to take advantage of the tax credit and incent homeowners to install solar panels who have a shorter time horizon or who otherwise balk at the up-front cost. One model, popularized by SolarCity but also employed by utilities, is to fund the up -front cost of installation and lease the array to homeowners over a term as long as 20 years. Certain utilities offer these services and also pursue the development of commercial- and utility-scale solar projects; they claim the tax credit and use it to offset the profits generated in their core utility business that are subject to full tax rates.

In some states, including New Jersey, the mechanism has been to create markets for the trading of credits. Solar developers create “SRECs”—Solar Renewable Energy Credits—that can be sold to industrial and other users to offset their carbon emissions. The prices of these SRECs have been volatile as a result of power prices, the cost of solar, and more recently, concerns about the phase out of the ITC. But as of May 2016, SRECs in New Jersey were trading at $0.29/kWh, reflecting a steady up-trend over the past four years.

Similar to the ITC, the production tax credit conveys to the commercial and industrial owners of wind, like MidAmerican, the Berkshire Hathaway utility, a rebate of (currently) $0.023/kWh of wind-powered generation for the first ten years of operation. As an example, a new 50 MW on-shore wind farm might cost $100 million to build; at a consistent 40 percent capacity factor, the annual tax credit could amount to $4 million, which over the ten-year life would decrease the initial capital cost by almost half (on an undiscounted basis). In a case study, we discuss the economics of a recent project—the Deepwater Wind Block Island Wind Farm (see Figure 2e on next page).

Perhaps one of the most interesting and highest profile recent examples of corporate investment in renewables is the case of Apple and First Solar. When CEO Tim Cook heralded Apple’s $848 million commitment to First Solar’s California Flats Solar Project, it was on the basis of meeting Apple’s commitment to sourcing 100 percent of its corporate electricity needs from renewable sources. Cook also stated that Apple would lock in a fixed price of electricity for 25 years at rates that are cheaper than other conventional sources and also immunize Apple from price increases implemented by the local utility. While Apple has agreed to purchase a fixed amount of the generating capacity through a PPA, there is some risk to First Solar that the California Flats output will be insufficient to meet the terms of the PPA, in which case, First Solar will have to procure power from the wholesale market. The risk stems from the fact that the capacity factor is not known with precision for the next 25 years.

Based on the information available, we believe the ITC is a critical component in making the economics of the project work for First Solar. Specifically, the investment only generates an IRR comparable to First Solar’s 9-10% return on assets with the 30% ITC; without the tax credit, the project appears to offer only a 6% IRR. This analysis assumes an installed cost of $2,000/kW; a 14% capacity factor, which is consistent with what utilities use in underwriting new solar investments; and that the initial price of electricity offered to Apple (and PG&E, the other customer signed on to take the balance of the output) is below the current California C&I rate of $0.137/kWh. [16]

The case of Apple is also interesting because it demonstrates that non-utility companies are becoming

Figure 2e: Deepwater Wind Block Island Wind Farm Case Study

In the fall of 2016 the Block Island Wind Farm off the coast of Rhode Island is expected to come online as the first utility-scale offshore wind project in the United States. While modest in scope at 30MW (by contrast, the world's largest planned offshore wind farm will have a capacity of 1,200 MW), the Block Island project represents an important step in the transition to a low-carbon future as the project has been financed and constructed entirely with private capital.

We presume that the private investors in the project—the project owner Deepwater Wind is backed by giant investment firm DE Shaw—expect to realize an attractive risk-adjusted return. With the data we found available through public sources, we analyzed the financial characteristics of the project.

Given the assumptions summarized below, some of which are inferred, we estimate the total pre-tax unlevered internal rate of return (IRR) on the project over 20 years to be 11.3 percent before accounting for the production tax credit. Interestingly, the PTC boosts the IRR, but only to 12.1 percent. The project's viability has much more to do with the power purchase agreement (PPA) price of electricity that the local utility—National Grid—has agreed to pay. At $0.244/kWh (with an annual inflation adjustment), the price of electricity generated is well above the statewide average retail rate of $0.15/kWh. However, Block Island's separation from the electricity grid and reliance on expensive diesel power means its residents already pay a summer rate of $0.24. Furthermore, National Grid is using the project as an opportunity to connect Block Island, and the wind farm, to the New England grid, conveying likely benefits of price stability and grid reliability, in addition to clean energy, to the residents of Block Island, and the rest of New England. Furthermore, while the cost of construction is quite high at nearly 10,000 $/kW, we note that there are numerous inefficiencies in this project (contracting ships from Norway, for example, to do the turbine installation) that would likely shrink as future projects create a local ecosystem of expertise and skills.

Block Island Wind—Project Economics

		Source:
Capacity (kW)	30,000	*www.dwwind.com*
Capacity Factor	47.7%	*Inferred*
Project Cost ($ million)	$290	*www.dwwind.com*
Equity ($ million)	$70	*www.dwwind.com*
Cost of Debt	5.0%	*Estimate*
Amortized Cost of Generation (kWh)	$0.214	*Estimate*
PPA Price	$0.244	*National Grid*
Unlevered IRR (pre tax, without PTC)	11.3%	
Unlevered IRR (pre tax, including PTC)	12.1%	
Levered IRR (pre-tax)	34.7%	

more directly involved in decisions related to how their electricity is generated. Like Tim Cook at Apple, leaders of more than 50 companies, including Bank of America, General Motors, Nike, Starbucks, and Walmart have committed to source 100 percent renewable energy. [17]

Another mechanism for financing energy efficiency projects (not limited to renewables development) has been the recent proliferation of so-called green bonds. In 2013, the Commonwealth of Massachusetts became the first US state to market and issue bonds whose funds were ear-marked for environmental projects such as energy efficiency improvements in state buildings, land acquisition and environmental remediation, and clean water and drinking water projects. The bonds themselves had the same credit rating and backing as other Massachusetts General Obligation bonds.

PRIVATE CAPITAL

While public funds are an important driver in the development of renewables, private capital also has an important role in financing low-carbon electricity generation, even if it is spurred by tax incentives. Globally, debt financing makes up the majority of private financing, with historically low interest rates providing a tailwind for low-carbon electricity deployment. The United Nations Environment Programme Finance Initiative reports that short term construction debt for a medium-sized renewable energy project in the United States has been available at 2.5-3 percent (or LIBOR + 150-200 basis points).

Corporations have also begun to issue green bonds and total green bond issuance has increased dramatically: Green bond issuance amounted to $42 billion in 2015, according to Moody's Investor Services, and is expected to surpass $50 billion in 2016. In February 2016, Apple issued $1.5 billion of green bonds to fund clean energy projects across its operations.

While green bonds have been marketed to investors who wish to participate in the development of renewables, based on trading patterns, we have not observed that these bonds offer issuers a lower cost of financing for "green" initiatives.

Another source of private investment has come from "tax-equity" investors. As discussed above, the ITC incents development of renewables through a rebate on income taxes. However, many renewable energy developers have little or no taxable income and therefore cannot directly take advantage of the tax benefit. In a tax-equity deal, the developer sells a portion of the tax credits anticipated to be realized through the development of the project to an investor who can put the tax credit to use in reducing his or her own tax liability. According to Bloomberg, about $11.5 billion in tax-equity investment deals for wind and solar were completed in 2015, which was up 14 percent from 2014. However, the number of investors participating in these deals remains small.[18]

Public equity investors have also recently had opportunities to invest in the development of renewables. Wall Street investment bankers and traditional utilities have together created the "YieldCo" model. YieldCos are essentially vehicles to own and operate generation assets whose output is sold under long-term PPAs to utilities and other electricity buyers. While the investment vehicles were originally designed as a way to market a sustainable bond-like return through the payout of all cash flow as a dividend (since most of the costs are borne up front), they have become a way for utilities to separate their renewable generation portfolios in response to investor demand for renewables (and yield) investment opportunities.

Despite raising a lot of capital from public equity markets, the performance of YieldCos has been volatile, in part we believe due to the untested nature of their business models. We investigate YieldCos further in Part 3 of our series.

Famed economist Robert Shiller theorized that "finance is not about 'making money' per se. It is a 'functional' science in that it exists to support other goals—those of society.

CONCLUSION

Renewable energy financing has emerged from many sources and is the result of a host of factors. Wind and solar electricity comprise nearly 100 percent of net new generation capacity added in recent years by US electric utilities. Renewables projects are approaching the point where they will offer a suitable investment return on an unsubsidized basis commensurate with the risk undertaken—a prerequisite for significant growth in private sector commitments. However, given the gap between what experts estimate is needed to address climate change ($840 billion per year) and the current level of annual investment ($348 billion), a critical question to ask is how much incremental renewable investment would occur in the absence of RPS, ITC, PTC, and other "carrots and sticks" that put a price on carbon pollution? Our research indicates the amount would be insufficient to achieve the transition to a low-carbon future necessary to avoid the worst impacts of climate change.

While any government intervention can have market-distorting consequences, we believe the government's role in supporting the development of the renewable electricity industry is appropriate and has precedent. The government is not a profit-maximizing entity and can invest on the basis of societal as well as financial benefits. Given the government's ability to take a longer-term view than most private investors, it can also assess the risks and costs of not making investments to lower our carbon emissions (e.g., higher health care and mitigation costs); private investors do not incorporate negative externalities into their IRR analyses, although perhaps they should.

Famed economist Robert Shiller theorized that "finance is not about 'making money' per se. It is a 'functional' science in that it exists to support other goals—those of society. The better aligned society's financial institutions are with its goals and ideals, the stronger and more successful the society will be.[19] With respect to the development of renewables at least, we tend to agree.

PART 3: INVESTMENT IMPLICATIONS

INTRODUCTION

A global commitment to reduce greenhouse gas (GHG) emissions and combat climate change is transforming entire industries, including the power generation sector, presenting opportunities and risks for investors. Creative destruction is producing new industry leaders, while also displacing incumbents, as it has repeatedly since the industrial revolution. The ultimate winners in past industry transitions have produced spectacular returns for investors. However, many companies fail along the way, impairing equity investments. Investors thus need to proceed with caution.

Investing in the transition of power generation from conventional to renewable sources currently presents the challenge of a limited availability of publicly traded companies and many speculative elements. Consistent with Walden's approach to invest in reasonably valued stocks of high quality companies with sustainable business models, we are taking a disciplined approach to investing in this transition. However, we remain enthusiastic about the potential investment opportunities that will undoubtedly arise from the transition to a low-carbon future, just as profitable investment opportunities have emerged from prior industry transformations.

As we highlighted in Parts 1 and 2 of our series, the generation of electricity in the US accounts for approximately one-third of GHG emissions, making it one of the largest contributors to climate change. The transition of US electricity generation from mostly fossil fuels to more renewable sources has been underway for years, driven by economics, regulations, technological advances, and consumer preferences. This transition is apparent when looking at new electric generation capacity, the majority of which has been renewable (wind and solar) over the past decade.

According to the US Energy Information Agency (EIA), in 2016 more than 60 percent of the 27 gigawatts (GW) of generating capacity additions were wind (9 GW) and solar (8 GW), while 33 percent (9 GW) was natural gas. (A gigawatt of renewable energy can meet the electricity needs of 200,000-300,000 homes.[1]) In addition, the EIA reports that another 3 GW of distributed (rooftop) solar capacity was installed in 2016. At the same time, 12 GW of capacity—primarily coal and natural gas—were retired in 2016.[2] Taken together, 100% of the net new electric generating capacity to come online in 2016 was renewable.

THE CHALLENGES OF INVESTING IN THE SHIFT TO LOW-CARBON ELECTRICITY

Despite the secular shift toward more wind and solar powered electricity generation, investors face a number of challenges investing in the transition. We address three specific challenges: the relatively small investment opportunity set, which appears to have a poor risk/return profile; new and unproven business models; and the challenge of analyzing companies in transition.

Small, Risky Opportunity Set

As a proxy for the renewable power investment opportunity set, we analyzed several industry-specific exchange traded funds (ETFs) offering exposure to renewables. The funds range from those focused purely on solar to those focused on smart grid, as well as others that include companies active in a broader range of industries (see Figure 3a on next page).

Within the funds analyzed, there were 213 unique companies, including 104 non-US companies. By way of comparison, there are approximately 3,600 stocks traded on US exchanges.[3]

The aggregate market capitalization of the renewable "pure plays" is relatively small. For example, the combined market capitalizations of the constituents of two solar focused ETFs (TAN and KWT) are $25 billion and $51 billion, respectively. This compares with the combined market cap of the US utility sector of approximately $805 billion. The entire solar industry is smaller than several individual large cap utility stocks.

The largest two funds we identified include companies that derive a *de minimis* portion of their revenue from activities

directly related to the transition to low-carbon electricity. The First Trust Global Wind Energy Fund (FAN), for example, holds significant positions in BP, Royal Dutch Shell, and Duke Energy, whose businesses are mostly exposed to fossil fuel extraction or traditional utility operations that significantly overwhelm their exposure to renewables development.

Moreover, the risk profile of most of these funds is relatively high, which is indicative of the underlying constituent risk profile. While performance as measured by total shareholder return has been mixed depending on the time period, the renewable funds have generally underperformed traditional market index benchmarks, as well as the conventional utility sector. Additionally, they have done so with higher volatility of returns, one proxy for market risk. Perhaps a more relevant measure of risk in the analysis of these companies is the risk of total business failure leading to permanent capital loss. Evergreen Solar and SunEdison exemplify this risk.

Furthermore, certain renewables investments, in particular solar equities, have exhibited greater correlation with oil and gas equities over the past five years than with the broader market. (The broader stock market has been negatively correlated with solar, oil, and gas stocks.) There is a certain irony in this given that renewables stand to benefit at the expense of fossil fuels, at least for power generation. But we think basic economics explains most of the pattern: in all three cases increases in supply of the underlying commodity—solar panels and domestic production of oil and gas—have flooded the market, depressing prices[4]. While this has led to poor returns for investors, it has been a boon for consumers.

New and Unproven Business Models

New and unproven business models present investors with another risk, despite the outlier effect some revolutionary firms have had in disrupting industries. "YieldCos," introduced in Part 2, provide a case in point. YieldCos are publicly traded stocks designed to provide investors a predictable low-risk return via a robust and growing dividend financed by their ownership of generally renewable power generating assets, such as solar and wind farms. In their current form, YieldCos entered the US market in 2013. By 2015, there were seven YieldCos, in aggregate representing approximately $23 billion in the public equity markets, which by some estimates was enough to cover one-quarter of US renewable financing needs since 2013.[5]

YieldCo assets have predictable revenue streams contracted under long-term power purchase agreements. As we discussed in Part 2, the variable costs of renewables power generation are low; therefore the YieldCo can forecast cash flows—and dividends—with a high degree of visibility.

Figure 3a: Competitive Performance of Select Renewable or Green Funds and Stock Market Indices

			Returns			Standard Deviation of Returns			Market Cap (billions)		
Name	Ticker	# of Holdings	1 Year	3 Year	5 Year	1 Year	3 Year	5 Year	Total of all Constituents	Average	Median
First Trust NASDAQ Clean Edge	GRID	37	22.4%	3.8%	9.5%	12.3%	14.1%	13.9%	$820.3	$22.2	$3.3
First Trust Global Wind Energy	FAN	44	14.3%	4.9%	12.7%	10.2%	16.2%	19.3%	$1,162.4	$28.4	$6.8
Guggenheim Solar	TAN	26	-19.6%	-24.7%	-3.6%	18.7%	30.5%	39.4%	$25.2	$1.0	$0.8
PowerShares Cleantech	PZD	53	19.1%	3.7%	9.2%	9.7%	15.3%	15.1%	$513.0	$9.5	$2.5
PowerShares WilderHill Progressive Energy	PUW	44	28.4%	-6.1%	1.2%	15.9%	22.6%	19.9%	$258.9	$5.9	$2.9
PowerShares WilderHill Clean Energy	PBW	40	1.3%	-15.4%	-4.1%	10.5%	21.1%	24.1%	$139.8	$3.5	$0.8
Market Vectors Global Alternative Energy	GEX	31	6.2%	-2.4%	10.4%	9.8%	17.8%	19.9%	$194.1	$6.5	$2.5
Market Vectors Solar Energy	KWT	27	-22.5%	-23.5%	-6.5%	17.1%	28.1%	35.4%	$51.3	$1.9	$0.8
Russell 1000®		997	17.4%	10.0%	13.3%	2.9%	7.2%	8.3%	$24,320.0	$24.4	$8.9
Russell Midcap®		794	17.0%	8.5%	13.1%	2.0%	8.0%	9.1%	$7,166.0	$13.9	$6.8
Russell 2000®		1946	26.2%	7.2%	12.4%	13.1%	15.7%	14.4%	$2,292.5	$1.2	$0.8
Russell 3000® Utility Sector		84	3.2%	9.2%	11.6%	9.8%	14.3%	13.0%	$804.8	$9.8	$4.1

Past performance does not guarantee future results.
Data is as of 3/31/2017, sourced from Bloomberg, and alphabetically sorted.

YieldCos tantalized investors with the prospect of robust dividend growth from the full pipeline of renewable assets that could be "dropped down" to them from their parent companies, most of which are regulated utilities. The assumption was that as YieldCo portfolios expanded, acquisitions of new assets could be financed at decreasing costs of capital. While low risk and predictability are markers of the high quality characteristics we look for in analyzing companies, the future growth prospects rested on the flawed assumption that these companies would have unlimited access to the capital markets at reasonable costs. They do not.

Following the initial market euphoria over YieldCos, the subsequent performance has been more risky and less predictable, as captured by the performance of the Global X YieldCo ETF (YLCO). Since inception on May 29, 2015, the fund has produced a cumulative total return of -18% (-10% annualized), including dividends. Over the same period of time the Russell 1000® Index of US large cap stocks returned 16% (8% annualized).[6]

We believe that YieldCos may be an important vehicle for channeling capital toward a low-carbon future. However, the future remains highly unpredictable, as it was for internet search providers in the 1990s, a case study of which is presented below. In the near term, YieldCos may experience further headwinds due to public policy uncertainty in the US. And, the relative yield from these "bond proxies" becomes less attractive if interest rates rise.

Companies in Transition

There are established companies that are participating in the industry transition via their own efforts in developing renewables. Regulated utilities NextEra and Avangrid are also two of the largest owners of "merchant" (unregulated) wind power, and have portfolios of assets well outside the service territories of their core utilities in Florida and the Northeast, respectively. NextEra has long owned traditional power generating assets, including nuclear facilities, but is re-shaping their portfolio toward greater use of renewables and less conventional power sources.

DONG Energy is a pioneer in the development of offshore wind, having launched the first offshore wind farm in 1991 and built more than 25% of global offshore wind capacity. The company's current focus on wind stands in stark contrast to its namesake origin: Danish Oil & Natural Gas.

A final example is Total SA. Based in France and one of the world's largest oil companies, it has recently begun investing in renewable energy. In 2011, Total purchased a 60% stake in SunPower, a renewable energy company specializing in developing solar projects. In 2016, Total purchased battery maker Saft Group SA for $1 billion. Total CEO Patrick Pouyanne has stated that, by 2035, 20 percent of the company's total energy output will be from low-carbon energy.

Companies that transition their business models to respond to shifting environments and new market realities should be well positioned in the future. However, it is not always clear or obvious that a company's leadership position in one industry will transfer to another. As such, we tend to exercise caution with respect to companies in transition.

The transition of US electricity generation from mostly fossil fuels to more renewable sources has been underway for years, driven by economics, regulations, technological advances, and consumer preferences... 100% of the net new electric generating capacity to come online in 2016 was from renewable sources.

Figure 3b: Internet Search Provider Case Study

Picking winners, ex ante, in any emerging industry is extraordinarily difficult. Internet search providers offer a case in point. In the late 1990s and early 2000s, the industry leaders included Altavista, Excite, and Lycos, all of which ultimately failed to create sustainable business models despite their first mover advantage. The prize in internet search went, of course, to Google. Google wasn't even founded until 1998, but now it dominates the search industry with 75% market share and generates $90 billion in annual revenue and $20 billion in profit. Even if you correctly foresaw the internet would be as important as it is today, before the dot.com bubble burst, it would have been difficult envisioning Google dominating this winner-take-all "market." We believe that we are still in the "late 1990s" with respect to the transition of US electricity generation.

INVESTMENT FOCUS FOR WALDEN

While Walden has sought to avoid emerging but unproven business models, highly volatile and speculative companies, as well as many companies in transition, we have sought to identify companies that can participate in the industry transition while also meeting our investment selection criteria. Specifically, we have long sought to identify companies—in all industries—that have a high quality financial profile, a sustainable business model, and are reasonably valued.

For example, as it pertains to the shifting sources of US electricity generation, we have identified regulated utilities such as Consolidated Edison (ED) and Eversource Energy (ES) as potential beneficiaries. Both companies own the underlying electricity grid infrastructure—wires, substations, transformers—that transmit electricity from where it is generated to where it is consumed. As the sources (and locations) of power generation evolve, we expect the electricity grid to be re-routed and these companies to benefit.

Among smaller cap companies, New Jersey Resources (NJR) is benefiting from this transition through its Clean Energy Ventures unit. In other industries we have identified companies that may benefit from increasing energy efficiency, less carbon intensity, and those deemed to have more sustainable business models throughout this transition.

Conversely, we seek to avoid most companies in industries that stand to be displaced by this transition. The suppliers of fossil fuels to coal burning power plants have seen declining demand for their product. We expect this will continue and so tend to avoid most stocks of companies operating in the extractive industries. We have also avoided most regulated utilities that own fossil fuel burning electricity generating facilities. In both cases we anticipate some degree of stranded asset risk to their long run sustainability as more and more electricity is generated by renewables.

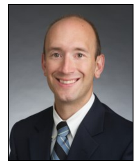
CONCLUSION

We began this three-part series expressing our support for the goal of the Paris Climate Agreement: limiting the increase in the global average temperature to below 2°C above pre-industrial levels, and pursuing efforts to limit the temperature increase to 1.5°C. We noted the importance of addressing GHG emissions associated with electricity generation, and that a transition to a low-carbon electricity grid was underway. Since first sharing our thoughts, one could say that so much *and* so little has changed. On the one hand, the political tide at the federal level has changed. The Trump administration, elected in part on the promise of bringing back jobs in the coal industry, signed an executive order calling for the review of the Clean Power Plan, effectively killing it. More recently, President Trump set in motion the multi-year process of withdrawing the US from the Paris Climate Agreement. On the other hand, the economics of renewable energy technology continue to improve; consumers—both individual and corporate buyers of electricity—continue to drive demand; and many other carrots (tax credits) and sticks (renewable portfolio standards) remain in place.

It is too soon to tell the short-term impact of these competing forces, but with each passing year the economics of renewable energy rely less and less on government policy intervention. We continue to support the goal of the Paris Climate Agreement, and we expect high quality companies with sustainable business models that are directly exposed to the transition to a low-carbon future to emerge positively from this seismic transition. While the high quality opportunity set remains limited in this area, we will maintain our research discipline and continue our diligent research to identify winners and losers and invest client assets accordingly.

Richard Q. Williams, CFA

Portfolio Manager



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REFERENCES

Part 1
All data on electricity in this article are sourced from the US Energy Information Agency (EIA), the statistical arm of the US Department of Energy.
[1] Climate Analytics. Feb 2015. In order to have more than a 50% chance of limiting warming to below 1.5°C by 2100, Climate Analytics estimates global GHG emissions by 2050 must be 70-95% below 2010 levels (65-90% below 1990 levels) and reach zero between 2060-2080, and global energy and industry $C0_2$ emissions must decline to zero around 2050 (range 2045-2055). For more details, visit climateanalytics.org/publications/2015/info-sheet-timetables-for-zero-emissions-and-2050-emissions-reductions-state-of-the-science-for-the-adp-agreement.html
[2] The balance of US GHG emissions come from transportation, industry, commercial, and residential sources and agriculture.
[3] This includes utility-scale solar generation only. In December 2015, the EIA began to include estimates of distributed solar generation (roof-top), which could increase net generation from all solar by as much as one-third.
[4] Source: US EIA, October 2015 Monthly Energy Review and EPA (https://www3.epa.gov/climatechange/ghgemissions/usinventoryreport.html). While the US climate commitment is to reduce greenhouse gas emissions by 26-28% by 2025, CO_2 emissions are only a subset of GHG emissions, which also include methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulfur hexafluoride (SF_6), and nitrogen trifluoride (NF_3). According to the US Environmental Protection Agency, 81% of US GHG emissions are from CO_2.

Part 2
All data on electricity in this article are sourced from the US Energy Information Agency (EIA), the statistical arm of the US Department of Energy.
[1] International Energy Agency. 2015. "Climate pledges for COP21 slow energy sector emissions growth dramatically." Accessed September 26, 2016. http://www.iea.org/newsroomandevents/pressreleases/2015/october/climate-pledges-for-cop21-slow-energy-sector-emissions-growth-dramatically.html
[2] Bloomberg New Energy Finance. 2016. "Clean Energy Investment In 2016 Undershoots Last Year's Record." Accessed September 26, 2016. http://about.bnef.com/press-releases/clean-energy-investment-2016-undershoots-last-years-record/
[3] McCrone, Angus et al. 2016. "Global Trends in Renewable Energy Investment 2016." Frankfurt School-UNEP Centre/BNEF.
[4] Disclosure: Certain Boston Trust and Walden portfolios own shares of Berkshire Hathaway Class B stock (BRK.B)
[5] For a review of the difference between installed capacity and actual generation, please refer back to Part 1 in our series. For more on MidAmerican Energy's 100% Renewable Vision, see https://www.midamericanenergy.com/our-renewable-energy-vision.aspx.
[6] A kilowatt hour (kWh) is the standard measure of electrical energy equivalent to the power consumption of 1,000 watts for one hour and is the common billing unit utilities use for residential customers. A 40-watt light bulb operating continuously for 25 hours uses one kilowatt-hour. According to the EIA, the average electricity consumption among residential users in the US was 10,932 kWh in 2014, ranging from a n average low of 6,077kWh in Hawaii to 15,497 kWh in Louisiana.
[7] As in Part 1, we attempt to compare costs using a "levelized cost of energy" or LCOE estimate. This includes fixed and variable operating costs as well as subsidies available at the time of calculation.
[8] A 2015 IMF working paper (How Large Are Global Energy Subsidies?) notes that estimates of global subsidies vary substantially depending on how subsidy is defined. Estimates, which range from $492 billion to $4.9 trillion, are significantly affected by whether and how environmental costs associated with fossil fuel energy consumption are estimated. For a summary of fossil fuel subsidies (narrowly defined) in the United States, see "United States – Progress Report on Fossil Fuel Subsidies," a report prepared by the US Department of the Treasury. In summary, the report notes 11 federal fossil fuel production tax provisions, amounting to $4.7 billion in annual revenue foregone. In Appendix 1 of the IMF working paper, the authors provide a summary of existing estimates of energy subsidies, including estimates from the OECD and International Energy Agency (IEA).
[9] SEIA. 2016. "Net Metering." Accessed September 26, 2016. http://www.seia.org/policy/distributed-solar/net-metering
[10] Barbose, Galen. 2016. "US Renewables Portfolios Standards- 2016 Annual Status Report." Lawrence Berkeley National Laboratory.
[11] US Department of Energy. 2016. "Investing in American Energy. Accessed September 26, 2016. http://energy.gov/lpo/about-us-home
[12] Mission Innovation. 2016. "Inaugural Mission Innovation Ministerial Pledges Unprecedented Support for Clean Energy Research and Development." Accessed September 26, 2016. http://mission-innovation.net/2016/06/02/inaugural-mission-innovation-ministerial-pledges-unprecedented-support-for-clean-energy-research-and-development/
[13] Mission Innovation. 2016. "Baseline and Doubling Plans." Accessed September 26, 2016. http://mission-innovation.net/baseline-and-doubling-plans/
[14] US Department of Energy and The Advanced Research Projects Agency-Energy. 2016. "About ARPA-E". Accessed September 26, 2016. http://arpa-e.energy.gov/?q=arpa-e-site-page/about
[15] US Department of Energy (DOE). 2016. "The SunShot Initiative: Making Solar Energy Affordable for All Americans." Accessed September 26, 2016. http://energy.gov/eere/sunshot/downloads/sunshot-initiative-fact-sheet
[16] If you would like to learn more about the assumptions underlying this analysis, please contact us.
[17] Disclosure: Apple (AAPL), Nike (NKE), Starbucks (SBUX), and Wal-Mart (WMT) stock are commonly held in certain Boston Trust and Walden portfolios.
[18] Eckhouse, Brian. 2016. "Clean-Energy Tax-Equity Investment Rising, But Not Fast Enough." *Bloomberg*, February 29, 2016. Accessed September 26, 2016. http://www.bloomberg.com/news/articles/2016-02-29/clean-energy-tax-equity-investment-rising-but-not-fast-enough.
[19] Shiller, Robert. 2012. *Finance and the Good Society*. Princeton: Princeton University Press. (Sourced from *Financial Analysts Journal*, Volume 72 Issue 3, pg. 24.)

Part 3
[1] A one gigawatt coal-fired power plant can provide sufficient electricity for approximately 640,000 homes, assuming an 80% capacity factor and average household electricity use of approximately 11,000Kwh. Because renewables have lower capacity factors (40% for wind and 25% for solar) than many conventional technologies a gigawatt of electric power generation of wind could provide electricity sufficient to meet the demand of approximately 320,000 homes, while a similar quantity of solar could power approximately 200,000 homes. Further complicating the issue is the intermittency of renewable energy, also discussed in Part 1 of our series.
[2] https://www.eia.gov/todayinenergy/detail.php?id=30112
[3] Center for Research in Securities Prices (CRSP) database as of March 31, 2017
[4] The explanation for the demand response is less straightforward. Utilities' demand for solar power and natural gas has increased as these sources have gained share, but supply growth has overwhelmed this demand increase, especially since aggregate demand for electricity is unchanged.
[5] "Beyond YieldCos," Climate Policy Initiative, June 2016.
[6] Bloomberg. As of March 8, 2017.