

Alternative Fuel Vehicle & Fueling Infrastructure Deployment Barriers & the Potential Role of Private Sector Financial Solutions

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■ EXECUTIVE SUMMARY

Broad deployment of alternative fuel vehicles (AFVs) can help address a range of concerns, including air quality, climate change, and energy security. For decades, the U.S. Department of Energy's Clean Cities Program and other federal, state, and local government initiatives have been facilitating the deployment of AFVs and fueling infrastructure to reduce petroleum consumption. In recent years, additional supportive public policies have helped accelerate the development and adoption of AFVs, which include electric, fuel cell, and natural gas vehicles. However, their numbers remain small and direct public support for both development and deployment is unexpected to reach levels seen following the federal economic stimulus in 2009. Significant growth of the AFV market, including new fueling infrastructure, will consequently depend on substantial increases in private investment. Innovative financial tools can play an important role in mobilizing this private capital.

As a first step in identifying promising solutions, it is critical to understand the fundamental barriers to AFV deployment, as well as specific barriers to AFV finance.

The major barriers to AFV market growth include:

- **High upfront cost of AFVs:** Currently, AFVs across all weight classes and fuel types are generally more expensive than similar gasoline or diesel vehicles. Government incentives designed to reduce the upfront costs have increased demand for AFVs, but not all buyers are able to use these incentives.
- **Inadequate near-term demand for widespread AFV fueling infrastructure:** While certain types of refueling infrastructure can be heavily used (e.g., airports and fleet hubs), development of more dispersed fueling infrastructure for all fuel types is limited by the demands of a smaller market.
- **Uncertainty about benefits and costs of AFVs and related infrastructure:** Consumers do not fully understand the vehicle total cost of ownership, performance, and fueling needs of AFVs.

Increased investment can help overcome these fundamental hurdles, but faces its own set of barriers:

- **Information failures:** Lack of credible, reliable information about new technology, including batteries (cost, life and recharging), and future

market demand for AFVs and fueling infrastructure limit interest in private sector financial solutions.

- **Legal and regulatory hurdles:** Rules about the kinds of financial instruments investors can hold, and restrictions on contract types and terms can both limit investment in AFVs and its infrastructure; this is especially true for government agencies.
- **Liquidity risk:** New technologies and new financial products initially face a market uncertain of their benefits and costs and are often considered more risky and harder to buy and sell, or in other words they are challenged by "liquidity" concerns. Rules around the liquidity of financial products and investment require banks to hold safe capital in reserve when they own assets that are harder to sell.
- **Scale:** The transaction costs associated with loan origination, attorney fees, monitoring, and servicing financial products are higher per product when only a few financial products are transacted. More transactions that use the same processes, templates and formulations reduce the per product cost.

Innovative financial tools have helped overcome similar barriers faced by other clean energy technologies, such as renewable energy or energy efficiency upgrades. Some financial models that have been helpful in advancing these technologies may also be useful in mobilizing stronger AFV investment. These include:

- **Leasing:** Various leasing plans allow any buyer to avoid high upfront costs and allow individual consumers and some government agencies to benefit from government incentives.
- **Performance contracting:** These contracts can be used to finance the higher upfront costs of AFVs or new fueling infrastructure. In both cases, the investment can be repaid through future operational and fuel cost savings.
- **Green banks:** These quasi-public or public financing institutions can leverage limited public dollars to attract significantly more private capital for investment. They can provide a variety of services including direct loans, contract standardization, and credit enhancements.

Although private finance and innovative financial tools

are not a panacea for AFVs and fueling infrastructure deployment, they can help overcome many of the barriers facing a new technology like AFVs. They can also engage a broader group of investors, secure longer loan terms, and ultimately reduce the costs of capital. These

■ INTRODUCTION

Alternative fuel vehicles (AFVs) are a small but increasingly important part of the U.S. transportation system. Powered by rechargeable batteries, natural gas, hydrogen, or other non-petroleum-based fuels, AFVs hold the potential to provide public benefits by reducing greenhouse gas emissions that are warming the planet,¹ improving energy security, and improving air quality. This paper makes the case that the benefits of AFVs are theoretically attainable today, but that due to the relative immaturity of the sector and market failures, deployment is unlikely to occur in a timely manner. Increased investment in deployment is essential to further improve the technology, increase scale to reduce per unit production costs, and catalyze the distribution of infrastructure. These factors are all critical to accelerate the adoption of AFVs.

At present, AFVs face several challenges in the vehicle market. While AFV buyers can generally access the same vehicle financing for AFVs and conventional vehicles, AFV prices are often much higher than those of gasoline or diesel vehicles. While lower operating costs for AFVs can compensate for higher purchase costs and ultimately make them cost-competitive over the vehicle's lifetime (some even without subsidies), other barriers to their deployment exist. Incomplete information about an electric vehicle's total cost of ownership, for example, can suppress AFV demand. Development of the necessary fueling infrastructure, which is essential to AFV deployment, has likewise not occurred because of uncertainty over the return on investment. This is due, in large part, to the limited number of AFVs on the road and their relative short history compared to conventional vehicles. Electric vehicles, for example, were first introduced to the mass market in late 2010, more than 100 years after large-scale production of automobiles began.

A combination of private financing and public funding has been helpful in addressing similar barriers in other

conditions would allow more potential buyers to enter the AFV market and help infrastructure providers survive until demand for their product, alternative fuels, is less diffuse and larger in scale.

markets that are now more mature, and could help address the early-market barriers facing AFV technologies as well. Public incentives and regulatory requirements have been the key drivers to developing and introducing AFV technology. The U.S. Department of Energy's Clean Cities Program, for example, has helped deploy AFVs and fueling infrastructure resulting in 5.4 billion gallons of petroleum saved since its inception in 1993.² While this and other federal, state, and local programs will continue to be critical for continued growth in the AFV and fueling infrastructure market, private finance can also play an important role in accelerating market growth for these technologies. In the building energy efficiency and renewable energy sectors, for example, innovative financing mechanisms, some of which leverage public funds and some of which do not, have helped these technology markets grow and mature. These financial tools or mechanisms were innovative in one of two ways: either as a completely new way of structuring a financial agreement, or as using an established financial tool in a new way.

While public funding has played a key role in advancing early AFV market development, a focus on private sector solutions for the market will be needed. Private sector solutions, such as leasing and performance contracting, tend to be more easily scalable than public support structures. Also, over time new public funding for deploying AFV technologies is likely to be limited.

Box 1. What's an AFV?

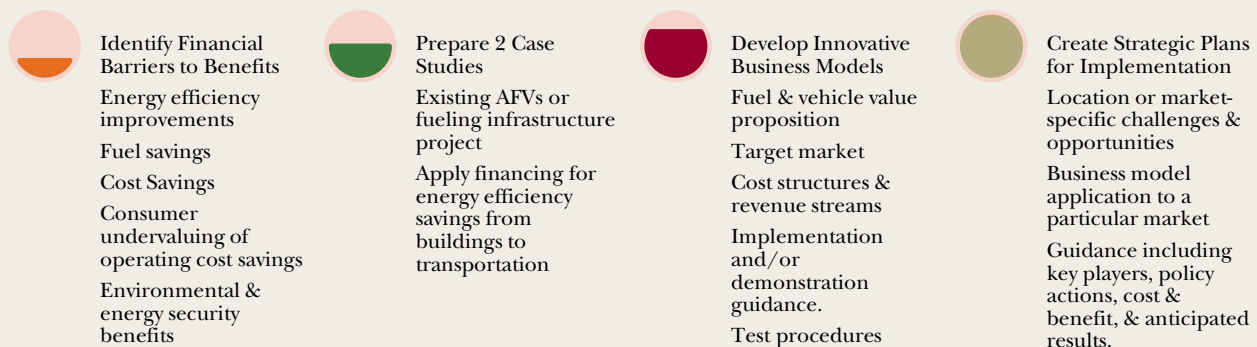
An AFV is any vehicle in the light-, medium-, and heavy-duty segment that can be powered by a fuel other than gasoline or diesel. Various combinations of vehicle drivetrains qualify as an AFV, including those powered in part by gasoline (e.g., an extended range electric vehicle like the Chevrolet Volt). The C2ES AFV Finance Initiative is focused on natural gas, electricity, and hydrogen type AFVs and the related fueling infrastructure (Box 2).

Box 2. C2ES AFV Finance Initiative

C2ES, in partnership with NASEO and with funding from the U.S. Department of Energy's Clean Cities Program, began a two-year initiative in early 2013 to develop innovative finance mechanisms aimed at accelerating the deployment of AFVs and fueling infrastructure. As part of this initiative, C2ES has assembled an advisory group of experts on AFVs, infrastructure, and finance from the public and private sectors to help guide its work. The AFV Initiative aims to:

- Identify barriers that hinder private sector investment;
- Develop innovative vehicle and fueling infrastructure financing models to make AFVs more accessible to consumers and fleet operators; and
- Stimulate private sector investment in AFVs and associated infrastructure deployment, building upon and complementing investments previously made by the public sector.

The initiative will research financial barriers, prepare case studies, and develop business models that state partners can consider piloting at the project's conclusion:



The initiative will not consider investment in product research, development, or manufacturing. While those areas are important considerations for AFVs, this initiative focuses on the deployment of the vehicles and the supporting fueling infrastructure.

The initiative specifically emphasizes two alternative fuels that offer significant opportunities for growth – electricity and natural gas. Hydrogen is also considered, but because hydrogen fuel cell vehicles are not expected to be available until 2015, this technology is not a focus of the paper. Notably, the initiative also does not focus on biofuels because many government and private sector stakeholders are already working to facilitate their deployment.

In addition to this paper, C2ES will also prepare case studies, and develop business models that states and other partners may be able to use as the basis for developing a pilot project that uses an innovative approach for AFV finance. More information is available at www.c2es.org/initiatives/alternative-fuel-vehicle-finance.

With the goal of increased deployment in mind, C2ES and the National Association of State Energy Officials (NASEO), with guidance from the AFV Finance Advisory Group, have started the AFV Finance Initiative to identify options for increasing private investment in AFVs and fueling infrastructure deployment (Box 2). Private investment, as used in this paper, is funding provided by investors with the intention of earning a positive rate of return. It does not include public money, ratepayer funds from electric or natural gas utilities, or investment by a

company in their own primary business line.

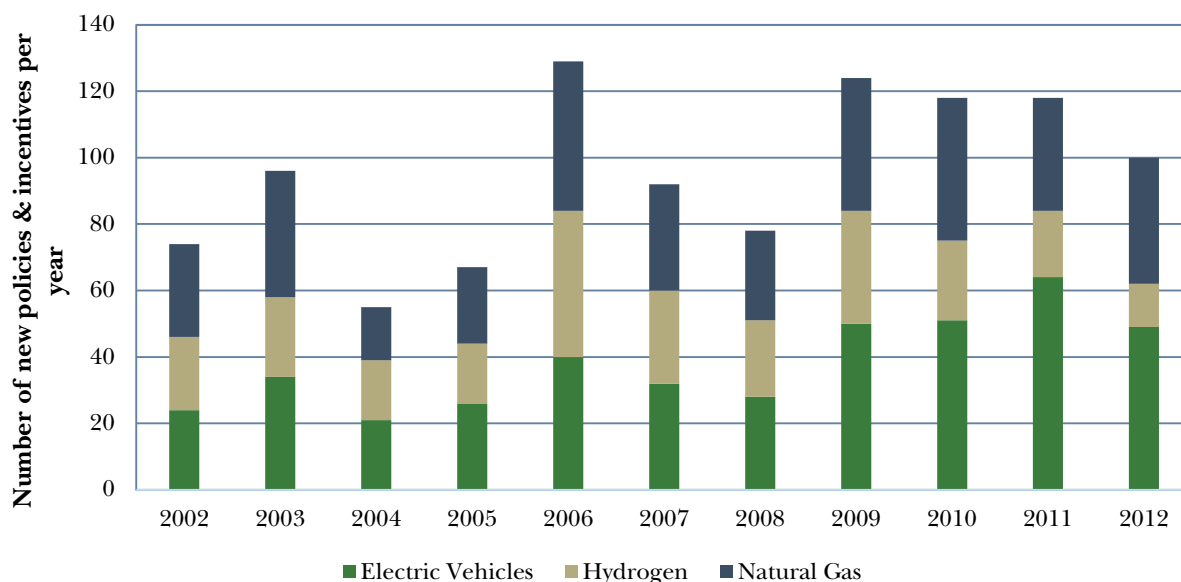
This paper examines how private financing can address the barriers to demand facing electric, natural gas, and hydrogen fuel cell AFVs and their related fueling infrastructure. Starting with a review of the state of the market, it covers significant barriers to market demand and barriers for private investors and concludes with a review of innovative finance options used in other sectors that could be applied to the AFV market.

■ AFV MARKET STATE OF PLAY

Air quality issues, climate change, and energy security impacts have prompted significant public policy attention to alternative-fuel vehicles, especially electric and natural gas vehicles. Both of these vehicle types use domestic energy sources that often release fewer local air pollutants and greenhouse gas emissions than diesel or gasoline.³ States have implemented a variety of incentives, including vehicle tax credits, exemptions such as high-occupancy (HOV) vehicle access, and rebates, to promote AFV deployment. Figure 1 highlights the number of new policies and incentives put in place each year. While the

number of new programs has recently declined on a year-to-year basis, many incentive programs are ongoing. Consequently, the cumulative number of incentive programs available for EV, hydrogen, and natural gas vehicles was more than 300 in 2012.⁴ In addition to the programs highlighted in Figure 1, many states have also committed to purchasing AFVs for their fleets; 22 states have committed to purchasing natural gas vehicles and eight have committed to purchasing zero emission vehicles.^{5,6}

FIGURE 1: Number of new state policies and incentives on AFVs (2002-2012)



Source: <http://www.afdc.energy.gov/data/10360>

At the federal level, tax credits exist for EV and hydrogen fuel cell vehicles up to \$7,500 for the former and \$4,000 for the latter. Federal fueling infrastructure tax credits and excise tax credits also exist for hydrogen infrastructure.⁷ Federal incentives for fueling infrastructure for EVs and natural gas vehicles expired in recent years.

In addition to government incentives and purchasing programs, the low operating cost of AFVs has also spurred interest in these technologies. The cost per mile to operate an electric passenger vehicle is about one-quarter the cost of the average conventional vehicle because of an EV's highly efficient drivetrain. Natural gas vehicles also operate at a much lower cost than gasoline or diesel vehicles because of the lower price per unit of energy for natural gas compared to petroleum. At the time of writing, compressed natural gas costs \$2.14 per gallon of gasoline equivalent, compared to \$3.65 and \$3.91 per gallon for gasoline and diesel, respectively.⁸ While prices do fluctuate, the price differentials between alternative and conventional transportation fuels are forecast to persist for decades, according to the U.S. Energy Information Administration (EIA).⁹

While the overall sales and use of AFVs have picked up in recent years, they remain a tiny fraction of new car sales and of the 250 million registered vehicles on the road today.¹⁰ EIA estimates that as of 2011, there were 189,472 natural gas, electric, and hydrogen fuel cell vehicles on the road in the United States.¹¹ Of these, natural gas vehicle have been in existence the longest and make up the largest share, accounting for about 64% of AFVs. The number of natural gas vehicles on the road (mostly pickups, buses, and trucks) has remained relatively constant from 2003 (117,046) to 2011 (121,650). While the number of these vehicles has remained relatively stable, their annual fuel consumption has actually increased 68% from 2003 to 2011.¹² This pattern of increased fuel consumption implies that natural gas

vehicle utilization rates, vehicle miles traveled, or both, are going up. Electric vehicle (EV) sales, however, are significantly increasing, even though their growth is still lower than initial forecasts made when EVs first hit the market in late 2010.¹³ Since then, the introduction of numerous new passenger models and state programs have helped EV sales grow considerably for individual consumers. U.S. sales from late 2010 to March 2014 exceeded 175,000, with nearly 40% occurring in California.^{14,15}

As fuel consumption increases, the stock of AFV fueling infrastructure has also experienced significant growth in recent years, especially electric vehicle charging stations. As of March 2014, the United States had 8,421 operating publicly available fueling stations for natural gas, electric, or hydrogen vehicles. Also, more than 95% of the nation's 7,689 public electric charging stations have been installed since 2010.¹⁶ A complete listing of AFVs and fueling sites is on the U.S. Department of Energy's Alternative Fuel Data Center website (www.afdc.energy.gov).

Infrastructure build-out requires a viable business model with sufficient demand and revenue from AFV operators. The fueling needs of AFV operators, however, are complex and vary by vehicle owner, vehicle type, and purpose (e.g., commercial or private individual). For example, operators of natural gas or hydrogen fleets, such as buses, cabs, and commercial vehicles, favor centralized refueling sites. In contrast, EVs tend to have more individual owners, so a home electric charging station is typically sufficient for daily driving needs. Nevertheless, there remains a need for workplace or other publicly available refueling sites for those without access to home charging (e.g., multi-family dwellers) and to alleviate the concern of EV drivers about range. Addressing concerns over fueling infrastructure is essential to grow AFV market share.

■ AFV MARKET PARTICIPANTS

Key participants in the AFV market vary widely and include large private and public vehicle fleet owners, individual consumers, AFV-related businesses, and investors (Figure 2). Considering their different

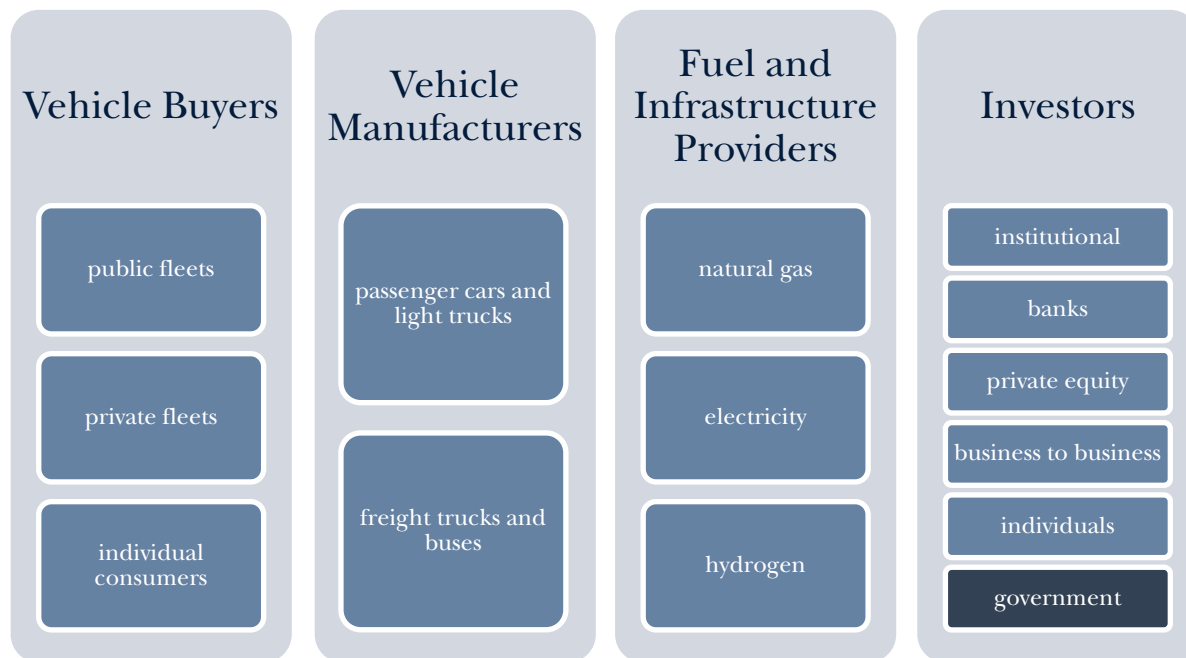
perspectives and constraints is essential to understanding the barriers restricting investment in AFVs and infrastructure.

Vehicle buyers tend to fall into three categories: public

fleets, private fleets, and individual consumers. These categories matter because the basis for purchasing decisions differs between the groups. A survey of individual car buyers, for example, found that their most important factors when buying a car included vehicle performance (82%) and design style (65%).¹⁷ Fleet buyers, however, tend not to be the drivers, so performance and style are less important. Instead, fleet buyers are more likely to base their decisions on vehicle

suitability, serviceability, price, and lifecycle cost.¹⁸ Among fleet buyers, public and private entities also vary in their operational requirements. For instance, public fleet managers base purchasing decisions on strict budgeting rules, such as the potential inability to shift funds from their operating budget (for vehicle maintenance and fueling) to their capital budget (for vehicle and infrastructure purchasing).

FIGURE 2: Key AFV Participants and Stakeholders



Vehicle manufacturers are another category of participants in the AFV market. Manufacturers tend to be large, established companies that have been making conventional vehicles for decades, but have more recently begun to include AFVs as part of a portfolio of vehicle offerings. For passenger cars, these include General Motors (Chevrolet Volt), Nissan (LEAF), Toyota (Plug-in Prius), and Honda (FCX Clarity), while bus and freight trucks manufacturers like Blue Bird, Freightliner, and Mack similarly each produce natural gas vehicles. Tesla Motors and Smith Electric produce only EVs, and are notable exceptions.

Air quality requirements and fuel economy standards have both contributed to growth of the AFV market. Natural gas buses were often first introduced in cities that

could otherwise not attain ambient air quality standards imposed by the U.S. Environmental Protection Agency. For instance, Los Angeles Metro first introduced natural gas buses in 1995 to help address air quality issues, and now relies on natural gas to power nearly all of its bus fleet.¹⁹ In addition, California and nine other states are requiring automakers to build zero emission vehicles (ZEV) and offer them for sale within their borders. ZEV requirements have been instrumental at inducing the development and manufacture of hydrogen fuel cell and electric vehicles (and their related infrastructure).^{20, 21}

Fuel and infrastructure providers are another category of stakeholder involved in the AFV market. Companies that provide fueling infrastructure include those solely focused on installing and operating AFV fueling stations,

companies that provide fueling infrastructure as an ancillary service (e.g., a restaurant that provides EV charging), and companies that have interests in electricity, natural gas, and hydrogen production and sale. The latter stakeholder category tends to face strict restrictions on the investments they can make as the distribution and sale of natural gas and electricity are regulated by the state government. Depending on the state, changes to electricity or natural gas infrastructure, retail rates, or new programs may require approval by a public utility commission.²²

Investors are the fifth category of market participants essential for increasing AFV and infrastructure deployment. Governments were some of the earliest investors and continue to provide significant funding for development and usage. Incentive programs, subsidies, education initiatives, and purchasing for government fleets all contributed to the start up of this industry. While government may be considered an initial investor, generally throughout this paper, investors can be thought of as those that provide money or capital for a limited period of time in exchange for an expected positive financial return. While the term “investor” is a general term, the investor community is far from homogenous, as investors vary with respect to their tolerance of risk over different time horizons and hurdle rates of return (see Appendix for definitions of financial terms). Some of these differences are rooted in institutional regulations. For example, regulated financial institutions, like banks, have rules that make owning new securities without a history of returns challenging, even if they believe they have a return exceeding their hurdle rate.

Large institutional investors (e.g., pension and mutual funds) and banks have numerous regulations regarding what they can own, especially for assets seen as very risky. Scale and the ability to sell their investments, if needed, are key considerations for this group, both of which are more difficult to overcome at the onset of a new financial instrument, such as new AFV or infrastructure financial products.

At the other end of the spectrum, private equity firms are able to enter into high-risk investments and to have significantly more debt compared to equity (i.e., highly leveraged). Thus, investment in AFVs and infrastructure

can be much easier for less regulated investors. A subcategory of private equity, venture capital firms, often invest in companies at the earliest stage of their development when risk of failure is higher. In fact, venture capital originally funded Tesla Motors.

Private and publicly traded businesses as well as individuals can be anywhere along the spectrum. Businesses investing outside their own companies (business to business), as well as individual investors, can use the above types of firms to invest, or they can directly invest themselves, in AFV-related projects. Publicly traded businesses must report on their investments, but do not have as many rules or regulations as institutional investors or banks. Individuals, of course, face few regulations about where they can put their money but often make a significant portion of their investments through institutional investments like mutual funds or pensions.²³

For those AFV investments that are not self-funded, financial markets can play an important role. In the simplest arrangement, investors provide capital and recoup loan repayments or potentially earn a return or dividend on equity arrangements. A slightly more complicated arrangement could include a type of service company that acts as an intermediary between the primary investor and the user/purchaser of the AFV or infrastructure. A service company might be used because it could provide performance guarantees (e.g., a guarantee of savings from decreased energy use) or use a leasing arrangement rather than a direct sale in order to reduce the risk for AFV buyers. Another role for the financial community could be in creating a secondary market where loans for assets are pooled and resold to investors. In other clean tech markets, secondary market investors pay primary market investors upfront in exchange for the future repayments from vehicle buyers or fueling infrastructure providers. In this type of arrangement, repayments generally go through a loan servicing company, which is responsible for billing and processing payments. The loan servicing company then remits payments to secondary market investors subtracting servicing or other costs. A wide variety of arrangements are possible and depend on the needs of all market participants, including legal budgetary requirements.

■ BARRIERS TO DEMAND THAT PRIVATE FINANCE CAN HELP OVERCOME

Private finance can help address some of the most significant barriers to demand for AFVs and fueling infrastructure. Table 1 summarizes the most significant barriers to market demand and barriers for private investment in AFVs and fueling infrastructure. The table defines barriers facing each stakeholder category from Figure 2, including barriers that are specific to each stakeholder. Although private finance is not a panacea for AFVs and fueling infrastructure deployment, it can be used to overcome some of the most challenging barriers to demand including:

- **High upfront cost of AFVs:** Currently, AFVs across all weight classes and fuel types are generally more

expensive than similar gasoline or diesel vehicles. Government incentives designed to reduce the upfront costs have increased demand for AFVs, but not all buyers are able to use these incentives.

- **Inadequate near-term demand for widespread AFV fueling infrastructure:** While certain types of refueling infrastructure can be heavily used (e.g., airports and fleet hubs), development of more dispersed fueling infrastructure for all fuel types is limited by the demands of a smaller market.
- **Uncertainty about benefits and costs of AFVs and related infrastructure:** Consumers and investors do not understand the vehicle total cost of ownership, performance, and fueling needs of AFVs.

TABLE 1: Summary of Barriers to AFV Deployment

CATEGORY	STAKEHOLDER	BARRIERS TO AFV DEPLOYMENT
<i>Vehicle Buyers</i>	All	High upfront cost; lack of infrastructure; lack of information and experience; lack of scale; absence of industry standardization; vehicle availability
	Public fleets	Capital and operating budget limitations; restricted access to public incentives; ineligibility for auto manufacturer lease specials
	Private fleets	Ineligibility for auto manufacturer lease specials
	Individual consumers	Ineligibility to qualify for, or lack of interest in accessing, tax credits, public grants, and/or auto manufacturer lease specials
<i>Vehicle Manufacturers</i>	All	Small market/limited demand; technological development; uneconomical technology
<i>Fuel and Infrastructure Providers</i>	All	Lack of AFVs on road; uncertainty about future market demand; absence of industry standardization
	Electricity	Small market and limited demand for fuel; low revenue from fuel leading to long payback period
	Natural gas	Small market and limited demand for fuel; low revenue from fuel leading to long payback period
	Hydrogen	Extremely small market; lack of vehicles available for purchase

Box 3. EV Battery Costs

The most expensive component of an EV is its battery. For example, the 2012 Ford Focus EV, priced at \$39,200, has a battery that is estimated to cost \$12,000 to \$15,000.³¹ In contrast, the gasoline-powered 2012 Ford Focus retails for \$22,000. On average, Bloomberg New Energy Finance estimates that batteries account for about 25% of the cost of EVs.³²

Private finance cannot help with other critical barriers such as lack of consumer education, regulatory restrictions (e.g., those preventing third-party resale of natural gas and electricity²⁴), or a lack of industry standards. These topics are beyond the scope of this paper.

HIGH UPFRONT COST FOR AFVS

Currently, AFVs across all weight classes and fuel types are generally more expensive than their conventional-fuel counterparts. Without incentives, buyers may have to pay more than twice as much for an AFV as they would for a model they perceive as similar that runs on conventional fuel.²⁵ For example, the 2014 base model Nissan LEAF, an EV, retails for \$28,980. Some compare the LEAF to the Nissan Versa Note, which is listed at just \$13,990.²⁶ A 2015 Chevrolet Silverado 2500HD bi-fuel truck fueled with compressed natural gas (CNG) or gasoline costs \$11,000 more than the equivalent gasoline-only model, a difference of 27%.²⁷ Similarly, heavy-duty trucks that run on CNG can carry a 40 to 80% price premium.²⁸

Attempting to address the high initial cost and increase demand, governments have used tax incentives and grants to reduce AFV prices. Not all buyers, however, are able to use these tax incentives. For instance, the federal government currently provides a tax credit of up to \$7,500 for every EV sold or leased.²⁹ If a vehicle buyer is a nonprofit or public entity or does not owe enough in taxes, they will not directly benefit from an EV tax credit. Likewise, the tax credit is not refundable, meaning that individuals that have less than \$7,500 in tax liability could not take full advantage of the credit. Tax credits can also confuse consumers and can be overlooked in the overall purchase incentives. On the other hand, California's Clean Vehicle Rebate Project issues a price reduction for

zero emission vehicles like EVs and hydrogen fuel cell vehicles at the point of sale.³⁰ A point-of-sale incentive directly lowers the purchase or loan amount.

Auto manufacturers have also tried to lower upfront costs by offering attractive lease deals on certain EVs. For example, manufacturers offered lease deals for as low as \$199 per month in mid-2013.³³ In some cases, individual dealers did not partake in these auto manufacturer lease specials. A Fiat dealer, for instance, reportedly did not participate in the manufacturer's lease special because the manufacturer required a dealer contribution to reach the \$199 per month lease price point it advertised.³⁴

Individual buyers may also be ineligible for AFV-related public grant programs, which often target fleets. For instance, the U.S. Department of Transportation's (DOT) Congestion Mitigation and Air Quality (CMAQ) program funds the incremental cost of an AFV over a conventional vehicle for private fleets and up to 80% of a vehicle's total cost for a public fleet.³⁵ A 2013 CMAQ grant for North Carolina's Solar Center dedicated \$4 million to alternative fuel vehicle and refueling equipment purchases, including money for public and private fleets.³⁶

Public and private fleets may need a third party to own equipment in order to smooth out the high upfront costs of buying AFVs and installing infrastructure over the lifetime of operation. As mentioned earlier, public entities cannot directly take advantage of tax credits. In addition, legal or operational restrictions can prevent public agencies from reallocating the fuel cost savings that will be realized in their operating budgets to their capital budgets to account for the vehicle's higher upfront costs.³⁷ Reallocation of funds from operating budgets to capital budgets can also be an issue for private fleets, because of corporate budgeting practices. A solution that can overcome both the inability to use tax credits and the operating versus capital budgeting issue is use of a third-party lease model. A third party that owns vehicles on behalf of the actual operator can take advantage of a tax credit and pass on part, or all, of the savings to the users and lessees of the equipment, including those unable or ineligible to use the credit. Nissan, for example, has a municipal lease program where Nissan Motor Acceptance Corporation claims the federal EV tax credit and passes on the savings to the municipality.³⁸ One drawback of this leasing model is the cost of borrowing for the third party could be higher than

what would be faced by a public agency because of factors such as bond issuance and better bond rates and higher volume.³⁹ However, this higher cost can be somewhat mitigated by shorter lease commitments that may allow the public agency to acquire lower-cost technology sooner.⁴⁰

INADEQUATE NEAR-TERM DEMAND FOR WIDESPREAD AFV FUELING INFRASTRUCTURE

Specialized infrastructure is required for delivery of all alternative fuels—natural gas, electricity, or hydrogen—just as specialized infrastructure is needed for conventional fuels. Similarly, this infrastructure can be targeted for individual, public, or fleet use. Generally, the requirements and practices for fueling infrastructure are identical for both public and private fleets. Some fleets require publicly available refueling for operators that travel long distances. The cost of installing infrastructure varies greatly by fuel type and fueling speed, as illustrated in Table 2. While certain types of fueling infrastructure can be heavily used (e.g., airports and fleet hubs), development of more dispersed infrastructure for all fuel types is limited by the demands of a smaller market. Uncertainty over the frequency of use for this fueling infrastructure, or utilization rate, is the primary barrier to installing infrastructure for all fuel types and prevents fueling infrastructure providers from reaching scale. Similar to vehicle deployment, government incentives

have encouraged AFV fueling infrastructure deployment, but with the same eligibility drawbacks. Again, private finance can help overcome these eligibility issues and issues related to low utilization rates through longer loan terms or lower interest rates.

Three primary issues make CNG/LNG infrastructure uneconomical for investors: (1) Existing gasoline and diesel infrastructure is often already in place and therefore competes well with new entrants; (2) The scale of fuel utilization seems insufficient to cover fixed costs; and (3) Home refueling may be unfeasible. Because natural gas vehicles are mostly used in fleet applications, CNG/LNG infrastructure providers tend to focus on onsite fueling for fleets rather than stations open to the general public. Many fleet owners already have conventional fueling infrastructure available either onsite or through public stations, so new infrastructure would be an added expense on top of the already higher cost for natural gas vehicles. In those cases, the cost of new AFV fueling infrastructure would be included in net present value calculations or other financial modeling. In the case of smaller fleets, fuel savings might not be enough to fully cover the cost of the fueling infrastructure.⁴¹ Finally, some fleets allow operators to take vehicles home, potentially requiring home refueling. In some cases, natural gas may not be available at the home, and in others, installation costs may be prohibitively expensive.

TABLE 2: Comparing Cost of Installing Alternative Fuel and Gasoline Stations

FUELING STATION TYPE	FUEL TYPE	PRICE RANGE FOR SINGLE STATION	FUEL COST PER MILE**
<i>Level 2 Home Charging Station</i> ⁴²	Electricity	\$400-\$5,500	\$0.03
<i>DC Fast Charging</i> ^{43,44}		\$50,000-\$150,000	
<i>CNG Home Slow-Fill Station</i> ⁴⁵	Natural Gas	\$5,000 + installation	\$0.08
<i>CNG Fast-Fill Station</i> ⁴⁶		\$675,000-\$1 million	
<i>LNG Fast-Fill Station</i> ⁴⁷		\$350,000-\$1 million	
<i>Central Generation Station</i> ⁴⁸	Hydrogen	\$1 million	\$0.09
<i>Conventional Station</i> ⁴⁹	Gasoline/Diesel	\$50,000-\$150,000	\$0.14

** Assumes an EV travels 3.5 miles per kilowatt-hour; a gasoline, diesel, or CNG vehicle travels 25 miles per gallon of gasoline equivalent; a hydrogen fuel cell vehicle travels 75 miles per hydrogen kilogram; electricity costs \$0.12 per kilowatt-hour; CNG costs \$2.10 per gallon of gasoline equivalent; hydrogen costs of \$7.00 per kilogram; and gasoline/diesel costs \$3.50 per gallon.

EV charging infrastructure providers face similar hurdles to CNG/LNG providers, and installing public infrastructure is less advantageous for EVs than natural gas vehicles. A publicly available fast EV charger can cost tens of thousands of dollars, depending on the extent of electrical work required, and the revenue from each use would typically be much less than from a natural gas or conventional vehicle. For example, refueling the 265-mile range Tesla Model S can cost \$10 or less.⁵⁰ In contrast, home charging stations are relatively inexpensive to install because most single-family homes require little electrical work to accommodate typical charging needs.⁵¹ This, in combination with the convenience of home charging for most, can reduce the need for publicly available charging stations. As a result of the low fuel cost and potential for low utilization, the payback on a public infrastructure investment for EV charging may take too long for investors without another revenue stream (e.g., advertisements) or some public subsidy.

On top of many of the hurdles described above, mass-market hydrogen fuel cell vehicles will not be available until 2015, which by itself makes hydrogen fueling infrastructure very challenging to deploy, considering it costs over \$1 million to install a single hydrogen fueling station. Home refueling of hydrogen is impractical because no hydrogen pipeline infrastructure exists and generating hydrogen on-site is cost-prohibitive at such a small scale.

Public incentives, like tax credits and grants, exist to facilitate the deployment of AFV fueling infrastructure, but face eligibility issues similar to AFV tax incentives. For instance, a tax credit for EV charging stations exists in New York, but public entities cannot use it because they do not pay taxes. Another example is the CMAQ program, which, as mentioned before, does not issue grants to individuals.

Private finance can address utilization and incentive eligibility issues for purchasing, installing, and maintaining fueling infrastructure through third-party lease models and longer loan terms. As described in the previous section, third-party lease models help convert tax credits into money and make it possible for ineligible parties, like public fleet operators, to take advantage of public incentives for fueling infrastructure. Longer loan terms and/or lower interest rates for fueling infrastructure providers can greatly reduce utilization issues by reducing monthly payments, which provide time

for utilization of fueling infrastructure to grow with AFV deployment. Table 3 illustrates that the monthly payments for a \$500,000 loan drop 55% when the loan length is increased by 200%, and drop 5% when the interest rate is decreased from 7% to 5%. The existence of the fueling station could create a virtuous cycle by reducing concerns of potential buyers about available infrastructure and induce more individuals or fleets to purchase AFVs, which could increase sales at the station.

TABLE 3: Loan payments for a \$500,000 amortizing loan

LENGTH OF LOAN	INTEREST RATE	MONTHLY PAYMENT
5 Years	7 %	\$9,900
15 Years	7 %	\$4,494
5 Years	5 %	\$9,436

INFORMATION-RELATED BARRIERS TO AFV PURCHASERS AND FUELING INFRASTRUCTURE PROVIDERS

Since AFVs and much of their infrastructure are relatively new, all vehicle buyers and fueling infrastructure providers have less experience with the technology and less data on their overall performance (including return on investment). Three of these key information barriers can be addressed, in part, through the use of private finance: vehicle total cost of ownership, uncertainty for vehicle buyers over costs and durability, and uncertainty around fueling needs.

As discussed earlier, the upfront cost of AFVs for all vehicle buyers creates a significant barrier relative to conventional vehicles. On a total cost of ownership basis, however, AFVs can have a lower total cost when incentives are factored in and fuel and maintenance costs are accounted for (see Box 4). Running on CNG, the Chevrolet Silverado 2500HD truck can save an average operator \$6,000 to \$10,000 in fuel costs over three years relative to the gasoline version.⁵² A similar situation exists for EVs, which can cost 80% less to operate per mile than a conventional vehicle.⁵³ A recent Electric Power Research Institute paper found that the Nissan LEAF would cost \$7,500 less than a 29-mile-per-gallon

conventional vehicle over the vehicle's lifetime when including current federal tax incentives.⁵⁴ For heavy-duty trucks, Waste Management indicates it is saving over \$30,000 per year in fuel and maintenance cost for each of the fleet's CNG trucks.⁵⁵

Box 4. Resources on Total Cost of Ownership

The Department of Energy has developed two tools for consumers to help with total cost of ownership. The first tool, the Vehicle Cost Calculator, available at <http://www.afdc.energy.gov/calc>, allows users to compare the cost of different light-duty vehicles on a total cost basis relying on vehicle use data entered by the user. The second tool, the Alternative Fuel Life-Cycle Environmental and Economic Transportation (AFLEET) Tool, available at <http://greet.es.anl.gov/afleet>, calculates the total cost of ownership for light- and heavy-duty vehicles powered by a number of alternative fuels.

A financial model that bundles fuel use and vehicle cost is one way of overcoming the total cost of ownership issue. For instance, a pay-per-mile model could provide greater cost certainty on vehicle ownership and operation and make it easier for consumers, including individuals and fleets, to realize the savings from AFVs. This financial model may be more practical for public and private fleets as long as AFVs have a small market share; a startup EV company called Better Place attempted to bundle the cost of the battery and fuel through a lease model and target individuals, but was unsuccessful.⁵⁶

Another information barrier for vehicle buyers is uncertainty over operating cost savings and vehicle durability. Tests and forecasts can estimate the durability and savings from the technology,⁵⁷ but the information may not be fully trusted until there is more real-world data. The primary uncertainty for natural gas vehicles is around the future price of natural gas, though the price is currently expected to stay low for many years according to the EIA. For EVs, the quintessential example of uncertainty is the usable life of the battery. The effects of frequent charging and discharging, weather, and other factors on the battery's longevity, combined with the

very high price of lithium ion battery replacement,⁵⁸ create a high level of uncertainty surrounding the lifetime cost of the vehicles.

Financial tools that enable renting, insuring, and even exchanging the battery can help overcome these uncertainties for consumers.⁵⁹ For instance, for \$100 a month, Nissan will replace a battery that loses more than 70% of its capacity,⁶⁰ restoring performance to this capacity or higher. Another way to increase the perceived value of an EV is to increase the value of reusing a battery, thereby capturing the residual value and adding a new cash flow prospect for this expensive item. For example, an EV battery could have up to 70% of its capacity remaining after 10 years in a vehicle. Finding new uses for this battery such as potentially providing backup energy storage services for a home or business could significantly reduce the total cost of ownership for an EV.⁶¹

For fueling infrastructure providers, uncertainties around fuel availability, market size, fueling needs, and siting considerations are the key issues. For natural gas and hydrogen, pipelines must be available unless onsite storage (or onsite hydrogen generation) is possible. Although access to electricity is largely ubiquitous, it may not be readily available or at the appropriate power level where vehicles are parked. Estimates of the AFV market size and fueling needs vary widely because it is difficult to predict future public policies, oil and natural gas prices, consumer preferences, and technological progress. Fuel providers may not know where to build publicly available infrastructure to maximize their customer base. In addition, local regulations, such as building and fire safety codes could restrict siting for fueling infrastructure. These risk factors will all reduce expectations for the potential return on investment.

As illustrated in Table 3, financial tools can help to overcome these barriers through a combination of longer loan terms, reduced loan rates, and other arrangements. For instance, debt covenants allow for less strict rules from a lender to a borrower and thereby make taking a loan less onerous. Better financing terms also improve the project calculus necessary to deploy and maintain infrastructure until utilization and revenue streams are sufficient. Financial arrangements, such as pooled project funding to build large infrastructure networks, can also help enable different debt structures when utilization rates are not sufficient.

This section provided evidence that private finance

can help overcome some of the most significant barriers to demand in the AFV market. Private investors, on the other hand, face their own set of barriers to investing in AFVs and fueling infrastructure deployment and can

make some of the ideas laid out above infeasible. The next section goes into the major barriers private investors face in the AFV market, followed by interventions to overcome these barriers from other sectors.

■ BARRIERS TO PRIVATE INVESTMENT IN AFVS AND FUELING INFRASTRUCTURE

Private investment and financial products come in a variety of forms and can help overcome many of the barriers to AFV demand highlighted earlier in this paper, especially reducing the upfront cost for vehicle buyers and infrastructure providers, reducing risk for consumers due to information uncertainty, and monetizing tax eligibility. Private investment, as defined earlier, is the money provided by various investors with the intention of earning a positive rate of return. Using private investment to create financial products is particularly important because financial tools can use operational savings, especially from fuel savings, to cover the higher upfront cost of vehicles or private fueling infrastructure. Additionally, longer loan terms or otherwise reduced costs of capital can help infrastructure providers survive until demand for their product, alternative fuels, is less diffuse and larger in scale.

A wide variety of private investment tools exist to help increase AFV and infrastructure deployment. Loans or debt instruments, securitization of asset loans and asset ownership, and leasing arrangements are all examples of investment tools (see Appendix) that AFV and infrastructure market participants might be able to employ. Many of these have been successfully used for other types of clean technology, including the renewable energy and energy efficiency sectors. In addition, expansion of AFV and infrastructure financing may create new types of assets—like an asset that consolidates the total cost of ownership for a vehicle, including fuel, into one payment—or may identify a new way of structuring asset payments.

While innovative investment tools can help deploy more AFVs and related infrastructure, private investment faces its own set of barriers including:

- **Information failures:** Lack of credible, reliable information about new technology, including

batteries (cost, life and recharging), and future market demand for AFVs and fueling infrastructure limit interest in private sector financial solutions.

- **Legal and regulatory hurdles:** Rules about the kinds of financial instruments investors can hold, and restrictions on contract types and terms can both limit investment in AFV and its infrastructure. This is especially true for government agencies.
- **Liquidity risk:** New technologies and new financial products initially face a market uncertain of their benefits and costs and are often considered more risky and harder to buy and sell, or in other words they are challenged by “liquidity” concerns. Rules around the liquidity of financial products and investment require banks to hold safe capital in reserve when they own assets that are harder to sell.
- **Scale:** The transaction costs associated with loan origination, attorney fees, monitoring, and servicing financial products are higher per product when only a few financial products are transacted. More transactions that use the same processes, templates and formulations reduce the per product cost.

While information failures similarly impact the demand for AFVs and infrastructure, the next section will explore how they inhibit private investment. More unique to private investors are legal and regulatory hurdles, liquidity risk, and the small scale of AFV financial products, all of which hinder significant investment in new financial products, especially for institutional investors and banks. All of these barriers are considerations for every type of investor and investment, but to varying degrees. For example, rules regarding financial holdings bar some institutional investors from owning securities that have not been rated by an approved rating agency. Furthermore, a lack of credible, reliable information affects all investors, but individual investors are most vulnerable because

they cannot leverage the specialized, skilled analysts that venture capitalists, a subset of private equity investors, tend to employ.

INFORMATION-RELATED BARRIERS TO PRIVATE INVESTMENT

Lack of credible, reliable information about a product, a company, and possible investment return can be a significant barrier to low-cost capital or use of financial models to help expand AFV deployment. Information-related barriers affect all types of investors. The limited history of EV battery life and their residual value, for example, make it more difficult to find investors or project developers willing to consider renting batteries rather than selling them. Renting EV batteries could reduce the price of a new EV substantially (Box 3) and reduce concerns about recharging time if the depleted, rented batteries could be swapped for fully-charged ones on a long drive. Investment in rentable batteries, though, is seen as highly risky given the lack of history with how long batteries last and with implementing a new model for owning just a portion of someone's vehicle. If investors do not have adequate information about costs, prices, rewards, the market, competition, and other factors, or if they simply do not feel the information is reliable, they will require a higher rate of return to compensate them for the uncertainty.⁶²

Another area of uncertainty important for investors is future market demand for AFVs and fueling infrastructure. The projections depend largely on consumer interest, public policy, and fuel prices. Government officials and some auto manufacturers had aggressive goals for EV sales at the market's outset in late 2010.⁶³ Even though companies and governments invested hundreds of millions of dollars in EV technology and its deployment⁶⁴ (and some even made a profit) many early projections⁶⁵ were not met, leaving investors with a smaller than expected market. Hence, though consumer demand continues to grow for EVs and sales have increased significantly since 2010, companies and investors may hesitate to believe current projections and make large capital investments in EV infrastructure.

Another information deficiency is experience with new technologies and their market. A financial manager from a large investment firm may not want to purchase a new type of financial instrument, such as an ABS backed by a pool of AFV auto loans or fueling infrastructure (paid

through operational savings similar to energy savings performance contracts), with which she has no history. If the ABS behaves differently or includes a technology the financial manager does not understand, it could be safer to simply avoid the new ABS until the first movers have provided more data on its returns and volatility. In some instances, there is no financial incentive to be the first mover, and therefore no additional profit to be made. Entering second may yield similar profits with significantly lower risk. In this situation, government incentives or risk sharing—where a public entity takes on some of the chance of investment loss—might be important to encourage first movers to invest.

LEGAL AND REGULATORY BARRIERS TO PRIVATE INVESTMENT

Legal and regulatory barriers can be especially pertinent for highly regulated investors like banks, pension funds, and insurance companies.⁶⁶ There are numerous rules about what types of financial instruments they can hold with relation to their overall portfolios' risk. For example, the Department of Labor restricts pension funds from owning securities without credit ratings from approved rating agencies.⁶⁷ For instance, new financial products, such as an innovative ABS backed by debt payments for AFV infrastructure, would not initially have a credit rating. The developers of the ABS would have to pay a credit rating agency for the rating, which requires a significant amount of information and history, especially to get an investment-grade rating. Both the cost and the information requirements for the ratings can be a high hurdle for new financial instruments.

Banking rules regarding liquidity, covered in the next section, require banks to hold safe capital in reserve when they own an asset that is harder to sell. These rules and regulations make investing in new instruments less attractive for banks.

Additionally, laws governing public procurement and the structure of competitive solicitations for goods and services can make some contracts, even ones that would save public agencies money, explicitly illegal. Thus, all types of investors and government agencies would not be able to participate, no matter the financial merits. For instance, Georgia's state constitution previously prevented state government agencies from entering into agreements that obligated current and future spending to prevent current legislators from creating funding

obligations for future government officials. This provision in the constitution, unfortunately, also prevented contracts that resulted in guaranteed costs savings. A constitutional amendment was passed in 2010 to allow multi-year energy savings performance contracts for natural gas, electricity, and water savings measures.⁶⁸ Multi-year agreements can help support private investment in the market by enabling the use of operating cost savings to pay for the higher upfront costs. Prohibiting them can limit private investment to increase energy efficiency or other operational cost savings measures.

LIQUIDITY RISK BARRIER

Liquidity risk is the risk that a financial instrument, like a new ABS that includes loans for AFV infrastructure, cannot be purchased or sold without a significant concession in price due to the small size of the market. To induce investors to provide capital for illiquid instruments, they must receive a higher rate of return. Some investor classes, including most private equity investors, are better prepared to deal with the lack of liquidity because they tend to hold investments for several

years. Nevertheless, liquidity is a consideration for all types of investors, affecting the required rate of return and even the number of such assets that can be owned.

Some financial institutions have legal limits on owning illiquid instruments, as mentioned in Table 4. If a highly regulated financial institution such as a bank buys a newly created and rarely traded, securitized pool of loans for AFV fleets, it will have to hold a larger amount of highly liquid assets, such as retained earnings. Holding this additional cash in reserve means that these retained earnings cannot be invested elsewhere, likely reducing future returns. Investors will require a higher return on their riskier investments to compensate them for the “opportunity cost” of having to hold more cash on hand. This is not only a legal and regulatory issue. Many investors do not want to own an illiquid asset or will require a very high rate of return to do so. Owning the assets could mean taking large losses if they want to rebalance their portfolio or take cash out for expenses. Once again, to compensate them for this reduction in flexibility, investors generally demand a higher return than for similar, but more liquid assets.

TABLE 4: Legal Regulatory Hurdles for Private Investors

CATEGORY	DESCRIPTION	EXAMPLES
<i>Banking and Financial Services Regulations</i>	Rules on what financial institutions can own and required reserve assets to counterbalance owning riskier assets	Ownership rules: Pension funds can only own securities with a credit rating from an approved rating agency. Reserve asset requirements: Upcoming banking regulations ⁶⁹ will require a higher proportion of safe capital holdings to balance owning illiquid assets, which a new AFV-related investment would be until a developed market is created.
<i>Contract Rules</i>	Rules and laws preventing use of certain types and terms of contracts; especially common for government agencies	Contract laws: Constitutional or other legal limits can prevent government agencies from entering into long-term contracts, such as prohibitions on state financial contracts longer than one year in Georgia.

Liquidity is an even larger concern for investments with longer timeframes, such as a 10-year or longer debt agreement. While longer loans help the buyer of an AFV

or developer of AFV infrastructure, they tend not to help the investor. The longer the term of the loan is, the greater the credit risk and the lower

the liquidity for the investor.⁷⁰

SCALE BARRIERS

Economies of scale exist in private finance just as in manufacturing (i.e., where the cost per unit falls when the total number of units produced increases). While scale affects all types of investors, it can be especially important for large investors, such as institutional investors. In the case of private financing, the costs are the transaction costs of the financial instrument, and the unit is the total dollar amount of capital. When the transaction costs for a deal or the ongoing loan monitoring and servicing costs are disproportionately high relative to the loan value, the interest rates must be higher to recoup the costs. As more high-value projects or more standardized, repeatable finance mechanisms come together, that ratio falls and the cost per unit of financing comes down. Standardization is important to overcoming scale barriers and can have a significant impact on the cost of capital.⁷¹

The Climate Policy Initiative found that institutional investors could provide a large amount of investment capital for renewable energy if certain barriers, such as scale, were addressed. The availability of capital is not the issue: “There may only be a shortage of opportunities at the price — and level of risk — that governments and energy consumers are willing to pay.”⁷² The authors analyzed the barriers for institutional investors and found two major obstacles are liquidity issues and scale—issues equally important to AFVs and infrastructure.

Small dollar deals or nonstandardized deals that require individualized setup can entail a significant amount of financial modeling, legal and risk analysis, and organizational work. Spread over only a small amount of capital, these fixed costs make the interest or other fees high per unit of capital. Increasing scale takes advantage of repeating the same processes and improving it. If loans for fueling infrastructure, for example, are standardized, banks can more easily and quickly assess risk, both for

origination and for selling the loans to other investors. The ability to sell the loans makes them more liquid, reducing the liquidity risk barrier. Standardization allows loans with similar terms and risk profiles to be pooled and sold in a secondary market, further increasing liquidity and decreasing the cost of capital. Additionally, selling the loans provides more capital to the originator, allowing them to make more loans and increase their economies of scale.

Developing and executing standardized contracts is one way the scale barrier for AFV-related projects can be addressed. If a large amount of individualized project finance origination work⁷³ has to be developed, for example, for a single \$1 million or more CNG fueling station owned by a third party, the cost of capital could be very high. But if the legal fees to develop a new, third party ownership finance contract were spread over five similar CNG stations, the per-unit development cost for financing a station could fall significantly.

As the market for AFV financial products reaches a larger scale, the financial products will tend to become more liquid, with more investors buying and selling them. The cost of financing will subsequently decrease, and, thus, will likely reduce the financing cost for consumers. This becomes a virtuous cycle, where larger scale and liquidity draw even more investors to the products and lower the cost of financing more. With this fall in financing cost, the total cost for AFV and infrastructure buying and deployment will also fall, increasing demand for AFVs and infrastructure.

Understanding the barriers to demand and to private finance is an important first step. Part of understanding them is also considering ways these barriers are not unique to AFVs or infrastructure, and how other sectors have addressed them. Some clean-tech sectors have already been successful at increasing demand and overcoming private investment barriers through innovative financial mechanisms. Lessons from these sectors are examined in the following section.

■ LESSONS LEARNED FROM PRIVATE INVESTMENT IN OTHER AREAS OF CLEAN TECH

Some renewable energy and energy efficiency technologies are similar to AFVs in that they are relatively

new technologies with high upfront capital costs and relatively low operating costs. In certain respects, however,

they are more advanced in their adoption than AFVs. More attention has gone into their deployment and, specifically, into funding mechanisms to overcome the higher upfront cost. For example, the Warehouse for Energy Efficiency Loans (WHEEL) program, created by Energy Programs Consortium and a team of public and private partners including NASEO, is working to create a secondary market for residential clean energy loans.⁷⁴ By creating a secondary market for loan originators, the program intends to reduce the cost of borrowed funds and increase the amount available for energy efficiency loans.

As the Clean Energy and Bond Finance Initiative⁷⁵ stated in its 2013 report on clean energy financing, “[h]ow competitive clean energy is with other energy technologies depends increasingly on what kind of financing is available and on what terms. So to reduce the overall cost of clean energy, the focus now also must be on reducing capital costs for clean energy investing.”⁷⁶ Inducing private investment is as critical for AFV and infrastructure deployment as it is for energy efficiency and renewable energy.

The following section explores three specific models—leasing, energy savings performance contracts, and green banks—that have been used to address the barriers for renewable energy and energy efficiency deployment and how these solutions could be applied to AFVs and their infrastructure. These three models were chosen due to both their success in increasing clean tech deployment and their ability to address important AFV and infrastructure barriers discussed in the paper. The ESCO and Energy Service Performance Contracts and the Clean Energy Banks examples will be explored further in the next stage of the initiative, the case studies.

LEASING

Leases are a familiar financial tool that could help increase consumer demand for AFVs and infrastructure. The lease model allows individual consumers and government agencies without a sufficient tax appetite to access government incentives. Additionally, leasing allows any AFV buyer to avoid the large, upfront expense.

Individual consumers commonly lease cars. The individual does not own the car but rather pays monthly to use the car for a specified amount of time, such as three years. A third party owns the asset, in this case the

car, using all the tax advantages, such as depreciation and, if available, tax credits. The user pays a fixed, monthly lease payment, returning the car or paying the third party a fair market price to buy it at the end of the lease period.

The leasing model is currently used in the solar industry, exemplified by SolarCity. The company installed 85 megawatts (MW) of residential solar power in 2012⁷⁷ and is the United States’ largest residential solar installer,⁷⁸ using leasing as a key component of its business model. SolarCity is vertically integrated, executing the finance, design, and installation for its projects. Other early solar installers generally left the financing up to the customer, but bank loans or self-financing through personal savings can be challenging for residential solar customers who are used to paying for electricity through a monthly bill, not a large, upfront cash payment.

SolarCity has overcome high upfront costs for customers by using a lease agreement where it or a third party owns the rooftop solar panels and the homeowner pays a fixed, monthly payment. SolarCity also offers a nonlease option, using a power-purchase agreement (PPA) where the homeowner pays for the power the system generates, at a lower price than the electric utility charges. With either option, the system can be installed at no upfront cost to the homeowner, with the opportunity to purchase the system outright at the end of the agreement. SolarCity operates in 14 states and plans to expand to any state where distributed solar energy generation is economically viable compared to utility generation.⁷⁹ The level of isolation, electricity rates, and the availability of incentives are important factors for the expansion of solar, including solar leases and PPAs.⁸⁰

The U.S. government is providing a tax credit of 30% of the total cost of installed solar power systems through 2016.⁸¹ However, homeowners might not have sufficient tax liability to make full use of the credit. Some tax benefits are only available to businesses. For example, most tangible assets, including solar systems, are eligible for depreciation, where a business can deduct the declining value of the asset to reduce its tax liability.⁸² The federal government even allows for accelerated depreciation specifically for solar systems. The business can claim a deduction greater than the system actually depreciates during the first few years of operation. This essentially gives the business a boost of liquidity since it owes less in taxes immediately after installation.

Individual tax filers cannot easily access this particular tax benefit.

Other credits exist that can raise revenue, such as solar renewable energy certificates (SRECs) available in some of the states where SolarCity operates. These credits are awarded for each megawatt-hour of electricity generated from a solar power system, and are valued by electric utilities needing to demonstrate compliance with a renewable portfolio standard.⁸³ An individual can sell SRECs, but it requires some knowledge and forecasting to understand when and how to sell them. All of these factors combine to make it less expensive for a solar project developer to install and own solar systems.

To take full advantage of the tax credits, SolarCity uses various financial structures with third party investors, including joint ventures and lease pass-through structures to convert the federal tax credit into money.⁸⁴ These structures allow investors with a tax appetite to take advantage of the tax credits to access the incentives and at the same time allows SolarCity to raise capital to install and operate solar power systems. The same applies to investors looking to tap federal, state, and local government incentives to deploy AFVs and fueling infrastructure. AFVs also have different tax credits, depreciation, and local public incentives for reduced pollution that make it less expensive to own and operate vehicles and infrastructure. Many of these are easier for businesses to access than for individuals.

Third party ownership and leasing of solar panels also helps overcome many information problems, including loan officers who are unfamiliar with the technology or lack information about long-term loan repayment history. In addition, the risk of significant financial loss for the homeowner is dramatically reduced, since they do not have to make an initial financial investment.

SolarCity's success with the lease model has boosted the use of third-party financing models. GTM Research estimates the annual investment in leased residential solar installations will grow from \$1.3 billion in 2012 to \$5.7 billion by 2016.^{85,86} The steady rise of SolarCity's stock price from \$8 a share in its initial public offering in December 2012 to \$75 a share in March 2014 is another sign of market confidence in leasing and SolarCity's business model.

Third-party ownership through leasing could be equally important for AFVs and infrastructure for the

same reasons. Just as with solar, the technology is new, financial mechanisms immature, and upfront costs high. Also, several federal, state, and local tax incentives are difficult, or nearly impossible, for most individuals or government organizations to use, including depreciation. Accessing both the depreciation tax advantage and the \$7,500 tax credit for EVs can be easier through a leasing program.

The leasing business model also helps overcome many of the financing information problems faced by both consumers and loan officers. Specifically, loan officers often lack information about the long-term loan repayment history of AFV buyers and, thus, may not make different loan terms for AFVs. In this case, this business model will be especially important for loans with higher loan-to-income ratios that rely on AFV owners using the fuel savings to cover higher payments, a concept without a long history for loan officers to study. Lastly, given that no large upfront payment is required, leases can alleviate car buyers' concerns related to EV technology, including battery life and resale value. Vertical integration that includes bundling the vehicle purchase, maintenance, and charging cost in one lease payment could reduce perceived risk for the total cost of owning and operating a vehicle.

ESCO AND ENERGY SERVICE PERFORMANCE CONTRACTS

Energy service companies (ESCOs) and energy savings performance contracts (ESPCs) use business models where the upfront capital costs for efficiency upgrades in buildings are financed, using the energy and water savings to repay the loan or other financial agreement.⁸⁷ This helps remove the hurdle of high upfront cost for the building operator and reduces the effect of other barriers such as risk aversion and lack of information or experience with the technology. Figure 3 provides a generalized perspective on the participants in the ESCO business model.

ESCOs and ESPCs have been fairly flexible and have been used to improve the efficiency of lighting, heating and air conditioning, windows, plumbing fixtures, natural gas, and water systems.⁸⁸ Many contracts guarantee the energy savings. In this contract format, an ESCO or an outside party guarantees that the energy savings will be enough to repay the project financing cost.⁸⁹ This protects the building owner or building management

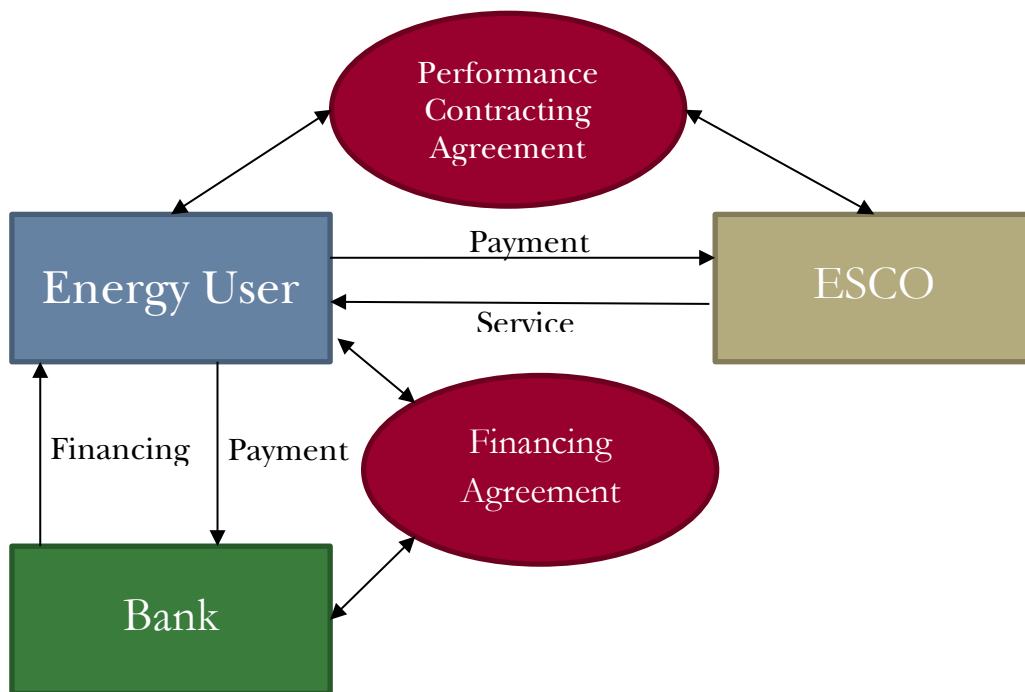
company from the uncertainty of future energy costs or finance repayments if the projected savings are not realized. The guarantee addresses building operators' concerns related to lack of reliable information about savings from energy efficiency upgrades. Reliable evaluation, measurement, and verification (EM&V) of the energy savings are key to the model's success.⁹⁰ A company will not guarantee savings if it cannot confidently evaluate the energy savings, measure the savings accurately, and verify the actual savings.

The model also helps clear some legal, regulatory, and institutional roadblocks by relying on an outside party to finance building upgrades. These contracts are especially popular in the public sector buildings market, with more than 85% of ESCO revenues coming from governments, schools, and hospitals in 2011.⁹¹ This is in part because governments, schools, and hospitals tend to have a higher tolerance than private companies for long payback periods. Furthermore, finding additional funds for energy efficiency upgrades can be challenging. During the depths of the recession, state and local governments

frequently had declining tax revenue and many are still struggling with tight budgets.⁹² By having an ESCO or outside party finance the upgrades through future energy bill savings, a sharp influx of public revenue is not necessary. Also, after the upgrades are paid off, the energy savings will reduce the ongoing expenses for operating the building, saving taxpayer money. Some ESCO contracts can even guarantee lower payments (for energy plus the ESCO payback payment) than the customer's previous energy bills in the near term, though lower near-term payments make the payback timeframe longer.

ESCOs can also combine energy efficiency building upgrades with onsite energy generation. Onsite renewable generation accounted for 6.4% of ESCO revenues in 2011.⁹³ As part of a larger energy savings contract, ESCOs are able to use government tax incentives that might be challenging for government entities or companies without a tax appetite to tap. Either the ESCO itself or a third party can take advantage of the available tax incentives, similar to the SolarCity example.

FIGURE 3: ESCO Business Model



An ESCO framework, with contracts based on ongoing fuel savings, can help finance AFVs and infrastructure. The lower operating costs based on reduced fuel expenditures decrease the total cost of ownership for a vehicle. Currently, natural gas vehicles have a higher upfront cost, as with energy efficiency upgrades for buildings, but the lower fuel price can offset the higher initial price over the life of the vehicle. For example, the price premium is \$11,000 for the bi-fuel Chevrolet Silverado 2500HD truck compared to the gasoline-only version.⁹⁴ The upgraded Silverado truck can run on CNG or gasoline. According to General Motors, over just three years the CNG truck can save an operator \$6,000 to \$10,000 in fuel costs, and more over the life of the vehicle.⁹⁵

If the vehicle user is unable to pay the additional capital cost of \$11,000 at the time of purchase, a contract similar to an ESPC can facilitate financing to cover the higher upfront cost, and the user could repay these costs through the ongoing fuel cost savings. This can be especially important for public sector buyers where increasing capital expenditures, even for lower operating costs, can be challenging. Adding natural gas fueling infrastructure can also be done through an ESCO-type model, where the cost of the new fueling infrastructure is paid for through future fuel cost savings. In fact, Colorado enacted a law in 2013 to allow government fleets to enter into energy cost savings contracts for AFVs and fueling infrastructure.⁹⁶

Another example of using an ESCO framework with AFVs is to combine EVs with solar charging. A third party could use solar system to capture federal tax incentives that public entities would be unable to use. The solar system could provide power for the EVs during the day and sell excess power back to the grid through a power purchase agreement with the electric utility or grid operate or through the state's net metering program.

CLEAN ENERGY BANKS

Clean energy finance banks or, as they are often called, green banks, use limited public dollars to attract significantly more private capital for investment. As described in this section, a clean energy bank is either a quasi-public or public financing institution that can address several of the barriers for private investors, create a market for new financial tools, and lower the cost of capital for clean energy and energy efficiency projects.

Examples include Connecticut's clean energy bank, a quasi-public institution established in 2011, and New York's \$1 billion bank, a public institution announced in January 2013, with the request for initial funds filed in September 2013.⁹⁷

Clean energy banks can be set up in numerous ways to provide direct loans for clean energy or to lower the risk for private investors. One key service a clean energy bank can provide is credit enhancement to shield private investors from the investment's first losses due to payment defaults or delinquencies, reducing risk in the initial phase of creating and selling new financial tools. Credit enhancements can be offered in many ways either by a clean energy bank or by another entity and can include a variety of options, such as sponsor equity and even insurance against nonpayment. In addition, credit enhancements can also help address information issues, illiquidity, and scale concerns by stimulating a larger market. All of these barriers are challenging for private finance to tackle in early-stage adoption. While there is little experience with, or research on, using clean energy banks to help with AFVs and infrastructure deployment, clean energy banks are being used to grow energy efficiency and alternative energy markets which initially faced many of the same barriers as AFVs. The Coalition for Green Capital found that clean energy bank interventions could make loan terms longer and lower loan costs by 2.25 percentage points, reducing the overall cost for clean energy projects by 15 to 20%.⁹⁸ Clean energy bank interventions, could similarly reduce the cost of capital and improve loan terms for AFVs and infrastructure. Longer loan terms could be especially useful for AFV infrastructure investments, where demand for public fueling is still small and the timeline for the return on investment long.

Clean energy banks like the one in Connecticut enable private investors to offer more money at a lower cost of capital due to the lowered risk. A new solar lease fund in Connecticut called CT Solar Lease II, for example, leveraged \$9.5 million in public funds for subordinated debt and sponsor equity as credit enhancements to attract \$50 million in private capital. The sponsor equity and subordinated debt would absorb losses before affecting senior debt repayments, which mitigates the risk of private capital losses in case some projects fail. In general, with bankruptcy or other debt default, there are different levels of seniority for debt repayment and often equity is

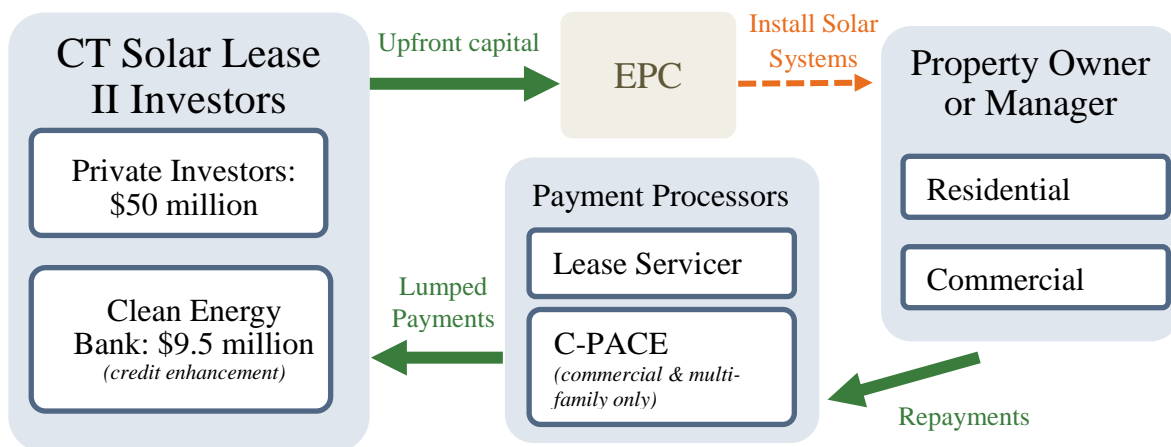
the last to be repaid. In this example, the clean energy bank owns the subordinated debt and equity, and thus would be the first and second to take losses. The two levels of protection on the senior debt provide more certainty for the private investors. If the solar lease program fails, the clean energy bank could lose its \$9.5 million investment first but the private investors are somewhat protected. Only losses greater than the \$9.5 million would fall on the private investors. The state is also somewhat protected. If the state or the clean energy bank directly made the full loan of \$59.5 million loan to the solar project and the project failed, the entire loss would fall to the state taxpayers. Instead, the state and the clean energy bank risk being the first to take a loss but they share the overall project risk with the private financiers. The combined funds will finance 14 megawatts of rooftop solar power for both residential and commercial properties.^{99, 100} The credit enhancements and increased scale are expected to ultimately make solar leasing less expensive.¹⁰¹

Figure 4 highlights the flow of funds in the existing CT Solar Lease II program in Connecticut. The combined \$59.5 million in capital is provided to local solar engineering, procurement, and construction firms (EPCs), which then install solar systems on homes and

commercial properties. The lease payments for the systems go either to a servicer or through Connecticut’s PACE program, C-PACE, which then remits the periodic payments to the investors.

In a similar manner, clean energy banks could help expand the market for AFVs and fueling infrastructure by providing credit enhancements that reduce private sector risk and attract additional capital. In fact, Connecticut’s bank explicitly lists AFV infrastructure as eligible for clean energy bank support, such as the credit enhancements in the Solar Lease II program.¹⁰² Lowering the risk for private investors in AFV-related projects will reduce the required rate of return necessary to attract private investors. A clean energy bank can also replicate this type of project over and over, which will yield more reliable data on energy performance and customer credit performance (reducing the aforementioned information barrier). Risk would then be lower for future projects because of better information. Finally, an additional benefit is that a clean energy bank can also be self-sufficient by earning a return on many of their investments,¹⁰³ creating a stream of income for new loans or credit enhancements without requiring new public funds.

FIGURE 4: Existing Clean Energy Finance Program (CT Solar Lease II)



■ CONCLUSION

Finding a way to encourage private investment in AFVs and fueling infrastructure is increasingly important, given the public benefits of AFVs—reducing greenhouse gas emissions, improving energy security, and improving air quality—and an increasing awareness among investors that climate change is affecting their portfolios. An essential first step in increasing private investment in AFVs and fueling infrastructure is to understand barriers that impede deployment, including the barriers to private investment. Each barrier has a different role in constraining market demand or restricting private investment. Overcoming each barrier involves a different set of actors who can work to address them. There is not one single answer; deployment of private finance to bring results is likely to come from a combination of policymakers, researchers, business leaders, and financiers.

This is far from the first new technology to make its way to Wall Street and private investors following years of government funding. AFV stakeholders can learn from recent successes in the renewable energy and energy efficiency markets. Initial lessons demonstrate the need for coordination across many public and private partners. Stakeholders from the public sector (including federal policymakers, state regulators, and local government officials), and from the private sector (including vehicle buyers, manufacturers, fuel providers, financial institutions, and investors) face different barriers

and have different tools at their disposal to overcome them. Focusing on barriers to private investment helps finance, business, and public sector stakeholders find common ground.

This broader group of investors and innovative financial products can bring down the upfront cost for vehicle buyers and infrastructure providers, decrease consumer risk associated with information uncertainty, and monetize tax eligibility. Additionally, longer loan terms, securitization of asset loans and asset ownership can all reduce the costs of capital and can help move the market toward self-sufficiency, reducing the need for public subsidies in the longer term. That is not to say that public funds are not needed at all. As with the green bank example, limited public funds can be used to leverage larger private investment to get a reasonable-sized market started.

AFVs and fueling infrastructure could be a key element of the transportation system if existing market deficiencies are addressed. While there are places for private companies to innovate and create returns for investors, reducing barriers to private finance is an essential part of increasing the size and scope of AFV adoption. AFV technology has already improved greatly in the past several years, yet there is room for more innovation and broader adoption. Addressing the financial barriers will allow private finance to provide greater assistance in advancing the AFV market.

■ APPENDIX: FINANCE TERMS

Asset: A resource with economic value that an individual, corporation, or government body owns or controls with the expectation that it will provide future benefit.

Asset backed security (ABS): A financial instrument whose income payments, and hence value, is derived from and collateralized (or "backed") by a specified pool of underlying assets that have a relatively similar or homogeneous risk profile. The pool of assets is typically a group of small and illiquid assets that are unable or unprofitable to be sold individually.

Debt covenants: Terms or restrictions in debt agreements that are put on a borrower by the bank or other entity that granted the loan. Requirements within a debt covenant might include the amount of leverage or other debt allowed for the borrowing company; or that they retain a certain amount of working capital or cash. If debt covenants are broken, often the loan becomes due immediately.

Property Assessed Clean Energy (PACE): A means of financing energy efficiency upgrades or renewable energy installations for buildings where the loans are repaid via an annual assessment on their property tax bill. The loan is attached to the property rather than an individual, remaining with the property and the new owner if the owner sells the property.

Credit enhancement: A tool to reduce credit risk by requiring collateral, insurance, or other agreements to provide a lender protection and assurance that it will be compensated if the borrower defaults. Basic forms of credit enhancement include, subordination (see subordinated debt), posting extra collateral, and letters of credit.

Credit rating: A grade by a rating agency indicating the potential default risk associated with a bond or issuing company.

Cost of capital: 1. Cost incurred in owning or borrowing capital, including interest payments and dividend payments. In order to provide an incentive for those willing to provide capital, the risk-adjusted return on the capital used to fund any given business needs to be higher than the cost of the capital; 2. The weighted average of the costs of debt and equity.

Depreciation: For tax purposes, businesses can deduct the cost of the tangible assets they purchase as business expenses in accordance with IRS or other taxing authority rules. For accounting purposes, depreciation indicates how much of an asset's value has been used up.

Debt instrument: An obligation that enables the issuing party to raise funds by promising to repay a lender in accordance with terms of a contract, including loans, bonds, and commercial paper. When a debt instrument is used as a medium to facilitate debt trading, debt obligations can be moved from one party to another quickly and efficiently.

Energy savings performance contract: A contract where a third party or installer pays for the upfront capital costs for efficiency upgrades in buildings, using the future energy and water savings to repay the loan or other financial agreement.

Hurdle rate: The minimum rate of return on a project or investment required by a manager, investor, or company. The riskier the project, the higher the hurdle rate, to compensate for risk.

Joint venture: A legal entity formed by two or more corporations, where equity stakes and operational control are shared in prescribed proportions.

Lease: A contract to allow the use of land or equipment by another without any transfer of ownership.

Lease pass-through: A legal structure that allows a lessor to pass on the tax incentives to a third party.

Liquidity risk: The hazard that a financial instrument, like a new ABS that includes loans for AFV infrastructure cannot be purchased or sold without a significant concession in price due to the size of the market.

Pooled assets: The grouping of assets that are to be repackaged into interest-bearing securities. The interest and principal payments from the assets are passed through to the purchasers of the securities.

Primary market: The market where securities, including loans, are first sold and the issuers receive the proceeds. Companies, governments, and other groups obtain financing through debt- and/or equity-based securities.

Rebalance portfolio: Process of readjusting the weighting of one's portfolio of assets or liabilities.

Retained earnings: Accounting earnings that are retained by the firm for reinvestment in its operations.

Secondary market: The market where securities, including those based on pooled loans or ABS, are traded among investors.

Securitization: The process of pooling types of debt to create securities that are backed by assets.

Sponsor equity: Cash investment by the owners of a project. The initial losses would come from the equity, before moving down to the least senior debt.

Subordinated debt: A loan or security that ranks below other forms of debt with regard to claims on assets or earnings.

Tax appetite: The ability and interest for a company or individual to use tax credits and other tax equity. It requires a tax liability, and thus profits or income, which can be offset by the tax equity.

■ ENDNOTES

- ¹ Greene, David, and Steven Plotkin. 2011. "Reducing Greenhouse Gas Emissions from U.S. Transportation." Center for Climate and Energy Solutions. January. Accessed December 4, 2013. <http://www.c2es.org/publications/reducing-ghg-emissions-from-transportation>.
- ² U.S. DOE. 2014. Clean Cities Goals and Accomplishments. December. Accessed March 12, 2014. <http://www1.eere.energy.gov/cleancities/accomplishments.html>.
- ³ C2ES. 2012. "An Action Plan to Integrate Plug-in Electric Vehicles with the U.S. Electrical Grid." Center for Climate and Energy Solutions. March. Accessed December 4, 2013. <http://www.c2es.org/initiatives/pev/action-plan-report>.
- ⁴ A complete list of currently available incentives at both the federal and state level can be found at www.afdc.energy.gov.
- ⁵ CARB. 2013. "Clean Vehicle Rebate Project." California Air Resources Board. September 4. Accessed December 4, 2013. <http://www.arb.ca.gov/msprog/aqip/cvrp.htm>.
- ⁶ The State of Oklahoma. 2012. Governors Fallin and Hickenlooper Announce Results of Successful 22 State CNG Vehicle Initiative. October 4. Accessed December 18, 2013. http://www.ok.gov/triton/modules/newsroom/newsroom_article.php?id=223&article_id=9308.
- ⁷ A complete list of currently available incentives at both the federal and state level can be found at www.afdc.energy.gov.
- ⁸ U.S. DOE Clean Cities. 2013. "Clean Cities Alternative Fuel Price Report." U.S. Department of Energy. July. http://www.afdc.energy.gov/uploads/publication/afpr_jul_13.pdf.
- ⁹ The growth rate of natural gas and electricity as a transportation fuel is lower than gasoline and diesel out to 2040, so the price advantage of these alternative fuels will only get better over time. <http://www.eia.gov/forecasts/aeo/>
- ¹⁰ U.S. DOT. 2013. Table 1-11: Number of U.S. Aircraft, Vehicles, Vessels, and Other Conveyances. May. http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_01_11.html.
- ¹¹ U.S. EIA. 2013. Alternative Fuel Vehicle Data. April 8. <http://www.eia.gov/renewable/afv/index.cfm>.
- ¹² The number of buses increased by 70 percent and bus fuel consumption increased by 112 percent (U.S. EIA. 2013).
- ¹³ Nigro, Nick. 2011. "Plug-in Electric Vehicles Market: State of Play." Center for Climate and Energy Solutions. July. Accessed December 4, 2013. <http://www.c2es.org/publications/plug-in-electric-vehicles>.
- ¹⁴ Hybridcars.com. 2014. Hybrid Market Dashboard. February. Accessed March 12, 2014. <http://www.hybridcars.com/market-dashboard>.
- ¹⁵ California New Dealers Association. 2014. California Auto Outlook. February. Accessed March 12, 2014. <http://www.cncda.org/secure/GetFile.aspx?ID=2668>.
- ¹⁶ Other fuel sites that are publicly available: 722 compressed and liquefied natural gas stations and only 10 hydrogen fueling stations. More information is available at <http://www.afdc.energy.gov>.
- ¹⁷ Consumer Reports. 2013. 2013 Car Brand Perception Survey. February. <http://www.consumerreports.org/cro/2013/02/2013-car-brand-perception-survey/index.htm>.
- ¹⁸ NAFA Fleet Management Association. 2012. "New Vehicle Acquisition Survey." Fleet Solutions, September: 12-18. <http://www.nxtbook.com/nxtbooks/naylor/NAFS0512/index.php?startid=12#/12>.
- ¹⁹ Los Angeles Metro. 2011. "A Billion Miles on Alternative Fuels." American Public Transportation Association. July.

Accessed December 4, 2013.

<http://www.apta.com/mc/sustainability/previous/2011/Presentations/A%20Billion%20Miles%20on%20Alternative%20Fuels.pdf>.

²⁰ States participating in the ZEV program are Connecticut, Maine, Maryland, Massachusetts, New Jersey, New York, Oregon, Rhode Island, and Vermont. More information is available on the C2ES website at <http://www.c2es.org/us-states-regions/policy-maps/zev-program>.

²¹ U.S. DOE. 2013. California Zero-Emission Vehicle Mandate is Now in Effect. March 18. https://www1.eere.energy.gov/vehiclesandfuels/facts/2013_fotw771.html.

²² Federal Energy Regulatory Commission. 2013. Natural Gas. November 6. Accessed December 6, 2013. <http://www.ferc.gov/industries/gas.asp>.

²³ Federal Reserve Board of Governors. 2013. "Financial Accounts of the United States: Flow of Funds, Balance Sheets, and Integrated Macroeconomic Accounts." September 25. <http://www.federalreserve.gov/releases/z1/Current/z1.pdf>

²⁴ States may consider the providing of EV charging services to be the equivalent of selling electricity and regulate providers as such. Restrictions on the sale of these fuels can result in providers being regulated as utilities and make some business models unworkable. In late 2013, the National Association of Regulatory Utility Commissioners (NARUC) passed a resolution encouraging states to institute reforms that would expand the alternative fuel market in states. Presently, many state legislators or public utility commissions still have not acted to address regulatory issues for alternative fuels that would enable a more diverse and potentially larger set of fuel and infrastructure providers.

²⁵ Comparing AFVs with conventional vehicles is challenging because of differences in driving performance and fueling needs.

²⁶ Nissan Motor Company. 2014. Nissan Cars, Trucks, Crossovers, & SUVs. Accessed March 12, 2014. <http://www.nissanusa.com>.

²⁷ General Motors. 2014. 2015 Chevrolet Silverado 2500HD. Accessed March 12, 2014. <http://www.chevrolet.com/silverado-2500hd-heavy-duty-trucks>.

²⁸ Reuters. 2013. Analysis: Thrifty truckers wary of pricey natural gas vehicles. March 22. Accessed November 19, 2013. <http://www.reuters.com/article/2013/03/22/us-trucks-natural-gas-idUSBRE92L07620130322>.

²⁹ Each manufacturer can receive tax credits of up to \$7,500 depending on the battery size in kilowatt-hours for the first 200,000 plug-in electric vehicles sold or leased. The credit is then phased out over a one-year period. For more information, visit <http://www.afdc.energy.gov/laws/law/US/409>.

³⁰ CARB. 2013. "Clean Vehicle Rebate Project." California Air Resources Board. September 4. Accessed December 4, 2013. <http://www.arb.ca.gov/msprog/aqip/cvrp.htm>.

³¹ Wall Street Journal. 2012. Ford CEO: Battery Is Third of Electric Car Cost. April 17. Accessed November 19, 2013. <http://online.wsj.com/news/articles/SB10001424052702304432704577350052534072994>.

³² Bloomberg New Energy Finance. 2012. Electric vehicle battery prices down 14% year on year. April 16. Accessed November 19, 2013. <http://www.newenergyfinance.com/PressReleases/view/210>.

³³ Consumer Reports. June. Electric car lease deals are the best way to drive an EV. 7 2013. Accessed November 19, 2013. <http://www.consumerreports.org/cro/news/2013/06/electric-car-lease-deals-are-the-best-way-to-drive-an-ev/index.htm>.

³⁴ Autoblog Green. 2013. Fiat 500e \$199 lease deal sounds great, is nearly impossible to get . July 23. Accessed November 19, 2013. <http://green.autoblog.com/2013/07/29/fiat-500e-199-lease-deal-sounds-great-is-nearly-impossible-to>.

³⁵ U.S. DOT. 2013. CMAQ and MAP-21. September 13. Accessed November 19, 2013. http://www.fhwa.dot.gov/environment/air_quality/cmaq/reference/cmaq_map21/index.cfm.

-
- ³⁶ North Carolina Solar Center. 2013. N.C. Solar Center receives \$6.2 Million grant for air quality solutions in North Carolina. May 21. Accessed November 19, 2013. <http://ncsc.ncsu.edu/index.php/2013/05/21/n-c-solar-center-receives-6-2-million-grant-for-air-quality-solutions-in-north-carolina>.
- ³⁷ Zhu, Charles, and Nick Nigro. 2013. "Plug-in Electric Vehicle Action Tool." Center for Climate and Energy Solutions. January. Accessed December 4, 2013. <http://www.c2es.org/pev-action-tool>.
- ³⁸ Zhu, Charles, and Nick Nigro. 2013.
- ³⁹ Miller-Crowley, Patti, interview by Nick Nigro. 2013. E-mail interview with Washington State Department of Commerce (December 12).
- ⁴⁰ Miller-Crowley, Patti, interview by Nick Nigro. 2013.
- ⁴¹ The Alternative Fuel Data Center's Vice Model assumptions allow a fleet manager to input key variables to understand the cost and savings from switching to CNG for fleets. See station cost assumptions in the AFDC excel spread sheet: http://www.afdc.energy.gov/docs/vice_model.xlsx.
- ⁴² Advanced Energy. 2013. Charging 101. Accessed November 19, 2013. <http://www.advancedenergy.org/portal/ncpev/charging.php>.
- ⁴³ Green Power Technologies. 2013. Green Power Technology offering DC Charger Incentive. December 2. Accessed December 4, 2013. <http://www.prlog.org/12250217-green-power-technology-offering-dc-charger-incentive.html>.
- ⁴⁴ NBC News. 2013. Tesla plans cross-country expansion of superchargers. May 30. Accessed November 19, 2013. <http://www.nbcnews.com/business/tesla-plans-cross-country-expansion-superchargers-6C10140066>.
- ⁴⁵ Dallas Business Journal. 2013. Skip the gas station and fuel up on CNG at home. May 3. Accessed November 19, 2013. <http://www.bizjournals.com/dallas/blog/2013/05/skip-the-gas-station-and-fuel-up-on.html>.
- ⁴⁶ ANGA. 2013. U.S. and Canadian Natural Gas Vehicle Market Analysis: Compressed Natural Gas Infrastructure. Washington, DC: America's Natural Gas Alliance. Accessed November 19, 2013. http://www.anga.us/media/content/F7D3861D-9ADE-7964-0C27B6F29D0A662B/files/11_1803_anga_module5_cng_dd10.pdf.
- ⁴⁷ Idaho National Laboratory. 2005. Natural Gas Technologies: Low-Cost Refueling Station. September 5. Accessed November 19, 2013. <http://www.inl.gov/lng/projects/refuelingstation.shtml>.
- ⁴⁸ California Energy Commission. 2011. DRIVE: California's Alternative and Renewable Fuel and Vehicle Technology Program - Projects. Accessed November 19, 2013. <http://www.energy.ca.gov/drive/projects/ARV-10-038.html>.
- ⁴⁹ Idaho National Laboratory. 2005.
- ⁵⁰ A Tesla Model S battery pack size can be up to 85 kilowatt-hours; at an electricity price of \$0.12 per kilowatt-hour, refueling the Model S would cost \$10.20.
- ⁵¹ Daily travel needs for many drivers can be met using Level 1 charging available from any standard 120-Volt power outlet. See <http://www.c2es.org/initiatives/pev/action-plan-report>.
- ⁵² Bloomberg. 2012. GM to Sell Pickups With Option to Burn Compressed Natural Gas. March 5. Accessed November 19, 2013. <http://www.bloomberg.com/news/2012-03-05/gm-to-sell-pickups-with-option-to-burn-compressed-natural-gas.html>.
- ⁵³ The cost per mile is about \$0.03 for an EV and \$0.14 for a conventional vehicle, assuming an EV travels 3.5 miles per kilowatt-hour, a gasoline vehicle travels 25 miles per gallon, electricity costs \$0.12 per kilowatt-hour, and gasoline costs \$3.50 per gallon.
- ⁵⁴ EPRI. 2013. "Total Cost of Ownership Model for Current Plug-in Electric Vehicles." Electric Power Research Institute. June 13. Accessed December 4, 2013.

<http://www.epri.com/abstracts/Pages/ProductAbstract.aspx?ProductId=00000003002001728>.

⁵⁵ Reuters. 2013.

⁵⁶ Washington Post. 2013. What Better Place's bankruptcy tells us about the future of electric cars. May 27. Accessed December 4, 2013. <http://www.washingtonpost.com/blogs/wonkblog/wp/2013/05/27/what-better-places-bankruptcy-tells-us-about-the-future-of-electric-cars>.

⁵⁷ American Chemical Society. 2013. Understanding the life of lithium ion batteries in electric vehicles. April 10. Accessed December 4, 2013. <http://www.acs.org/content/acs/en/pressroom/newsreleases/2013/april/understanding-the-life-of-lithium-ion-batteries-in-electric-vehicles.html>.

⁵⁸ U.S. DOE. 2013. "EV Everywhere Grand Challenge Blueprint." U.S. Department of Energy. January 31. Accessed December 4, 2013. http://www1.eere.energy.gov/vehiclesandfuels/electric_vehicles/pdfs/everywhere_blueprint.pdf.

⁵⁹ Forbes. June. Tesla and Nissan: EV Battery Swap Replaces Anxiety With Peace Of Mind. 21 2013. Accessed December 4, 2013. <http://www.forbes.com/sites/joannmuller/2013/06/21/tesla-and-nissan-ev-battery-swap-replaces-anxiety-with-peace-of-mind>.

⁶⁰ Nissan. 2013. Nissan Announces Battery Replacement Program for LEAF. June 20. Accessed December 4, 2013. <http://nissannews.com/en-US/nissan/usa/releases/nissan-announces-battery-replacement-program-for-leaf>.

⁶¹ ABB. 2012. ABB and partners to evaluate the reuse of the Nissan LEAF battery for commercial purposes. January 18. Accessed December 4, 2013. <http://www.abb.com/cawp/seitp202/a2b2d2aff96520bec1257989004e62ae.aspx>.

⁶² Recent studies have confirmed the correlation of information uncertainty and increased required rate of return or the market risk premium. One such study is, Jacoby Gady, Lee Gemma, Alexander Peseka, and Yan Wang. 2012. "Asset Pricing Theory with an Imprecise Information Set." Accessed December 5, 2013. http://www.world-finance-conference.com/papers_wfc2/283.pdf.

⁶³ Nigro, Nick. 2011.

⁶⁴ Government incentives included tax credits for EV purchases (up to \$7,500 per car) and loans, like \$1.4 billion to Nissan for the factory to build the Nissan LEAF (<https://lpo.energy.gov/?projects=nissan-north-america-inc>).

⁶⁵ U.S. DOE. 2011. "One Million Electric Vehicles By 2015: February 2011 Status Report." United States Department of Energy. http://www1.eere.energy.gov/vehiclesandfuels/pdfs/1_million_electric_vehicles_rpt.pdf.

⁶⁶ Board of Governors of the Federal Reserve System. 2013. "Press Release." July 2, Accessed December 5, 2013. <http://www.federalreserve.gov/newsevents/press/bcreg/20130702a.htm>.

⁶⁷ U.S. DOL. The Employee Retirement Income Security Act. United States Department of Labor. Accessed December 5, 2013. http://www.dol.gov/ebsa/regs/2000_ind_exemptions.html.

⁶⁸ Georgia Environmental Finance Authority. Energy Performance Contracting. Accessed December 5, 2013. <http://www.gefa.org/Index.aspx?page=513>.

⁶⁹ Bank for International Settlements. 2013. "Basel III: The Liquidity Coverage Ratio and Liquidity Risk Monitoring Tools," January. Accessed December 5, 2013. <http://www.bis.org/publ/bcbs238.htm>.

⁷⁰ Environmental Defense Fund. 2011. "Show Me the Money: Energy Efficiency Financing Barriers and Opportunities." July. http://www.edf.org/sites/default/files/11860_EnergyEfficiencyFinancingBarriersandOpportunities_July%202011.pdf.

⁷¹ Definitions for the cost of capital: 1. the opportunity cost of the funds employed as the result of an investment decision; the rate of return that a business could earn if it chose another investment with equivalent risk (<http://wordnetweb.princeton.edu/perl/webwn?s=cost%20of%20capital>). 2. The cost incurred in owning or borrowing capital, including interest payments and dividend obligations. In order to provide an incentive for those willing to provide capital, the risk-adjusted return on the capital used to fund any given business needs to be higher than the cost of the capital

(<http://lexicon.ft.com/Term?term=cost-of-capital>). 3. The weighted average of the costs of debt and equity (<http://hbr.org/2012/07/do-you-know-your-cost-of-capital/ar/1>).

⁷² Nelson, David and Brendan Pierpont. 2013. "Renewable Energy Finance and Climate Policy Effectiveness." March. Accessed December 5, 2013. <http://climatepolicyinitiative.org/wp-content/uploads/2013/03/The-Challenge-of-Institutional-Investment-in-Renewable-Energy.pdf>.

⁷³ Loan origination work includes legal filings, contracts, risk assessment and project modeling.

⁷⁴ NASEO. 2013 "WHEEL: A Sustainable Solution for Residential Energy Efficiency." National Association of State Energy Officials. Accessed December 5, 2013. http://www.naseo.org/Data/Sites/1/documents/committees/financing/documents/WHEEL_Primer.pdf.

⁷⁵ The Clean Energy Bond Finance Initiative is managed by the Clean Energy Group (CEG), a national nonprofit working on technology, finance, and policy in clean energy, and the Council of Development Finance Agencies (CDFA), the national organization of development and bond financing authorities in the United States. The Initiative receives guidance and support from the Task Force for Clean Energy Bond Finance, a national working group created by CDFA and CEG and composed of clean energy and development finance professionals. More information can be found at <http://cleanenergybondfinance.org>.

⁷⁶ Sanders, Robert G., Lewis Milford, and Toby Rittner. 2013. "Reduce Risk, Increase Clean Energy: How States and Cities are Using Old Finance Tools to Scale Up and New Industry." August. Accessed December 5, 2013. <http://www.cleangroup.org/assets/Uploads/2013-Files/Reports/CEBFI-Reduce-Risk-Increase-Clean-Energy-Report-August2013.pdf>.

⁷⁷ SolarCity. 2013. "SolarCity Announces Fiscal Year 2012 Update and Fiscal Year 2013 Guidance." January 5. Accessed December 5, 2013. <http://www.solarcity.com/pressreleases/156/SolarCity-Announces-Fiscal-Year-2012-Update-and-Fiscal-Year-2013-Guidance.aspx>.

⁷⁸ GTM Research. 2013. "U.S. PV Leaderboard." Accessed December 5, 2013 <http://www.greentechmedia.com/research/pv-leaderboard>.

⁷⁹ SolarCity SEC Filing. 2012 "SolarCity, Form S-1." October, 2012. Accessed December 5, 2013. <http://www.sec.gov/Archives/edgar/data/1408356/000119312512416770/d229977ds1.htm>.

⁸⁰ Pfund, Nancy. interview by Sarah Dougherty. 2013. (October 30).

⁸¹ U.S. DOE. 2013 "What You Need to Know About the Extended Federal Tax Credits for Energy Efficiency." February 27. <http://energy.gov/energysaver/articles/what-you-need-know-about-extended-federal-tax-credits-energy-efficiency>.

⁸² Database of State Incentives for Renewables and Efficiency. 2013. "Modified Accelerated Cost-recovery System (MACRS) + Bonus Depreciation (2008-2013)." Accessed December 5, 2013. http://www.dsireusa.org/incentives/incentive.cfm?Incentive_Code=US06F.

⁸³ Solar Renewable Energy Certificate (SREC) Markets: Status and Trends, NREL, <http://www.nrel.gov/docs/fy12osti/52868.pdf>. Not all states where SolarCity operates have SRECs. Thus, each state and municipality with different incentives will have different factors and streams of income for solar leasing projects.

⁸⁴ SolarCity SEC Filing. 2013. "SolarCity, Form 10-Q." June 30. Accessed December 5, 2013. 10Q filing: <http://secfilings.nasdaq.com/filingFrameset.asp?FileName=0001193125-13-327486.txt&FilePath=20130809&CoName=SOLARCITY+CORP&FormType=10-Q&RcvdDate=8%2F9%2F2013&pdf>.

⁸⁵ GMT Research. 2013. "U.S. Residential Solar PV Financing: The Vendor, Installer and Financier Landscape, 2013-2016." February. <http://www.greentechmedia.com/research/report/u.s.-residential-solar-pv-financing>.

⁸⁶ Goossens, Ehren. 2013. "U.S. Home Solar Financing to Reach \$5.7 Billion by 2016." *Bloomberg*. February 11. Accessed December 5, 2013. <http://www.bloomberg.com/news/2013-02-11/u-s-home-solar-financing-to-reach-5-7-billion-by-2016.html>.

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- ⁸⁷ International Finance Corporation. 2011. "IFC Energy Market Service Company Market Analysis." June 23. <http://www.ifc.org/wps/wcm/connect/dbaaf8804aabab1c978dd79e0dc67fc6/IFC+EE+ESCOS+Market+Analysis.pdf?MOD=AJPERES>.
- ⁸⁸ Davis, Andre E. "Using Performance Contracting and Incentives to Accelerate Energy Efficiency Projects" Accessed December 5, 2013. http://www.johnsoncontrols.com/content/dam/WWW/jci/be/white_papers/GIWhitepaper.pdf.
- ⁸⁹ ICF International National Association of Energy Services Companies. 2007 "Introduction to Energy Performance Contracting." October. Accessed December 5, 2013. http://www.energystar.gov/ia/partners/spp_res/Introduction_to_Performance_Contracting.pdf.
- ⁹⁰ Kapur, Namrita. 2011. "Show Me the Money: Energy Efficiency Financing Barriers and Opportunities," July. http://www.edf.org/sites/default/files/11860_EnergyEfficiencyFinancingBarriersandOpportunities_July%202011.pdf.
- ⁹¹ Larsen, Peter H. 2013. "Current Size and Remaining Market Potential of U.S. ESCO Industry." Presentation to Energy Services Coalition Market Transformation Conference August, 13. Accessed December 5, 2013. <http://conference.energyservicescoalition.org/wp-content/uploads/2013/08/Peter-Larsen.pdf>.
- ⁹² Data from Tax Policy Center. "State and Local General Revenues FY 2004-2001." Accessed December 5, 2013. http://www.taxpolicycenter.org/taxfacts/Content/Excel/dqs_table_64.xls.
- ⁹³ Larsen, 2013
- ⁹⁴ General Motors. 2014.
- ⁹⁵ Bloomberg. 2012.
- ⁹⁶ OpenStates.org. 2013. Fleet Vehicle Energy Cost-savings Contracts. June 5. Accessed December 13, 2013. <http://openstates.org/co/bills/2013A/SB13-254>.
- ⁹⁷ Nicholls, Mark. 2013. "New York's green banker,". *Environmental Finance*. April 2. Accessed December 5, 2013. <http://www.environmental-finance.com/content/analysis/new-yorks-green-banker.html>.
- ⁹⁸ Berlin, Ken, Reed Hundt, Mark Muro, and Devashree Saha. 2012 et al.'s "[State Clean Energy Finance Banks: New Investment Facilities for Clean Energy Deployment](#)." September. Brookings-Rockefeller. Accessed December 5, 2013. <http://www.brookings.edu/~media/research/files/papers/2012/9/12%20state%20energy%20investment%20muro/12%20state%20energy%20investment%20muro.pdf>.
- ⁹⁹ Solar Industry Magazine. 2013. "Securities Firm Helps Launch CT Solar Fund." August 1. Accessed December 9, 2013. http://www.solarindustrymag.com/e107_plugins/content/content.php?content.13042
- ¹⁰⁰ CEIFA. 2013. "Agenda Item #2, Public Comments." Presentation to the Board of Directors of the Clean Energy Finance and Investment Authority. June 26. Accessed on December 5, 2013. http://www.ctcleanenergy.com/Portals/0/board-materials/CEIFA_BOD%20Meeting_Special_062613.pdf.
- ¹⁰¹ Friedrich, Kat. 2013. "Connecticut's New Solar Lease Program Will Kindle Economic Opportunity." June 30. Clean Energy Finance Center. Accessed December 5, 2013. <http://www.cleanenergyfinancecenter.org/2013/06/connecticuts-new-solar-lease-program-will-kindle-economic-opportunity>.
- ¹⁰² CEIFA. 2013. "Comprehensive Plan: FY 2013 through FY 2015." Clean Energy Finance and Investment Authority. Accessed December 18, 2013. <http://www.ctcleanenergy.com/Portals/0/FY13%20Comprehensive%20Plan.pdf>.
- ¹⁰³ Berlin. 2012.



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