Energy Technology Loan Guarantee Programs: The Search for Additionality in Support of Commercialization

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April 4, 2014

1.0 Introduction

The United States federal government uses a variety of financial tools to encourage the development and deployment of energy technology. Until the 1970s these tools primarily consisted of tax benefits aimed at assisting the exploration for, and production of, fossil based energy sources (Vietor, 1984). The oil shortages and gasoline price spikes triggered by the Arab Oil Embargo of 1973 brought simmering concerns about energy security to the forefront of political discourse (Yergin, 2009). The embargo arguably gave rise to the modern age of US energy policy in which serious discussion regarding domestic energy supplies moved beyond oil, coal, and natural gas to include consideration of a wider range of energy sources (Solomon and Krishna, 2011). While some of the resulting discussion focused on developing methods for producing synthetic fuels, the energy security concerns of the oil embargo also combined with the burgeoning environmental movement to produce federal support for the development and commercial deployment of renewable energy technologies (Cavanagh et al., 1989). That federal support encompassed new mechanisms including, for the first time, the use of federal loan guarantees to help secure financing for the commercialization of clean and renewable energy projects (Herrick, 2003). To date, a thorough and information driven assessment of the effectiveness of such loan guarantee programs has not been performed. The analysis presented in this paper is a first step toward such an assessment.

Loan guarantees that aim to aid in the development and deployment of energy technologies are shaped by, and targeted at, specific steps of the innovation process (Ogden et al., 2008). The last few stages in the innovation process are related to commercialization and are the stages in the energy technology innovation process in which financial support is ideally transferred from the government to private enterprise (Balachandra et al., 2010). However, commercializing energy technologies can require substantial capital investment that is too large for venture capital and too risky for either private equity or debt financing. The result is a “commercialization gap” in which private financial entities are not willing to put the capital at risk necessary to bring a technology to market (Yanosek, 2012).

Ideally, federal loan guarantees help bridge this “commercialization gap” by reducing the risk associated with lending to a specific project or company. A loan guarantee is a pledge by a third party to repay all or a portion of a borrower’s outstanding debt to a lender in the event of borrower default (Angoua et al., 2008). In a federal loan guarantee program, a federal agency is the third party guarantor. A lender benefits from a guarantee agreement via reduced loan risk, and that benefit is ideally passed on to a borrower by enticing private entities to make credit available (CBO, 2013) or by reducing the interest rates charged by private lenders on credit that is already available (Fried, 1983). In contrast to private loan guarantors, there is generally no mechanism that enables government to earn a direct financial return on a guarantee program; any fees collected are allocated to administrative expenses and default costs (CBO, 1978).

Loan guarantees provide a return to government via leveraging the private sector to advance policy (Honohan, 2010). Since the 1973 oil embargo, energy policy has been influenced to varying degrees by the externalities associated with different energy systems and the market’s failure to internalize the costs and benefits of those externalities (Finon, 1994). For energy systems, the two most prominent externalities that have been used to justify government intervention have been energy security and environmental impact (Brown, 2001). Government support for cleaner sources of electricity generation target negative environmental externalities while support for renewable fuels and electric vehicles target both environmental concerns and potential benefits that can be achieve from reduced dependence on oil imports. Loan guarantees have been used to aid in directing private credit toward the creation of domestic industries that will support the government's energy policy goals (Morries et al., 2012). However, those broader goals of reducing environmental impact and increasing energy security are likely better measured in terms of metrics such as reductions in CO_2 emissions and production volumes resulting in decreased fuel imports (Brown and Mosey, 2008).

The primary justification for a loan guarantee program is its ability to generate additional lending to a targeted class of borrowers (Vogel and Adams, 1997). Measuring additionality in large and continuous guarantee programs (such as those used to support small business and housing in the United States) can be very challenging. Such measurement requires estimating which guaranteed borrowers would have received financing without a loan guarantee and subtracting those borrowers from the overall pool of guaranteed loans. In contrast, loan guarantees for the commercialization of new energy technologies potentially offer a simplifying assumption for measuring additionality. The governing legislation for most of the programs require that borrowers prove they have been unable to obtain financing via normal channels. Assuming such proof is confirmed, each loan made under a commercialization guarantee program could be considered evidence of additionality. However, history offers some evidence that lending would have occurred anyway, and the legislative language does not address substitution issues.

Loan guarantee programs aimed at commercializing new technology also entail a second major justification, which is the normalization of private credit relationships between lenders and borrowers. This is a learning-by-doing justification in which it is expected that the initial lending relationships incentivized by government guarantees will aid borrowers in learning how to obtain private financing while simultaneously aiding lenders in gaining more information about a given borrower and the technology that is the target of the guarantee program (Vogel and Adams, 1997). Unfortunately, the confidential nature of private credit relationships makes obtaining accurate and dependable information on normalization exceedingly difficult.

The purpose of this paper is to examine the extent to which applicable past and present loan guarantee programs have been successful in generating credit market additionality in support of energy technology commercialization. No attempt is made to quantitatively evaluate the impact of programs on normalizing private credit relationships due the potentially insurmountable difficulties inherent in making such a determination. Given that the success of loan guarantee programs is predicated on the extent to which they induce additionality, there is little reason in attempting a formal cost-benefit analysis or comparison of alternatives in the absence of additionality (Vogel and Adams, 1997). Therefore, the exploration of additionality presented in this paper seeks to form a foundation for more rigorous policy analyses than those currently available.

After reviewing applicable loan guarantee programs this study found that roughly 15% of the projects that received guaranteed loans had, or may have, the potential to generate credit market additionality in support of energy technology commercialization. In most cases, the remaining 85% of projects failed prior to completion or shortly after beginning operation, were not financed by private institutions, or the technology was commercialized independent of the loan guarantee program in question. The commercial evolution of some technologies suggests that a loan guarantee program was unnecessary.

The structure of the rest of this paper is as follows. The next section provides a literature review and outlines the methods used to analyze additionality and commercialization. The third section discusses results of the analysis for given programs, technologies, and projects in historical context, beginning with the first phase of projects that took place in the 1970s and 1980s followed by the second phase that commenced in 2005. The fourth and fifth sections of the paper provide supporting information and discussion regarding the programs reviewed in the paper. The final section of the paper summarizes the conclusions drawn from the work, explains the significance of those conclusions, and provides recommendations for further research.

2.0 Methods and Literature Review

In general, US federal loan guarantee programs that have supported the commercialization of clean and renewable energy technologies have operated in two phases. The first phase of loan guarantee programs began in the mid-1970s and continued through the 1980s. The second phase of programs began in 2005 and is currently active. Table 2.1 summarizes the loan guarantee programs examined in this paper. The date ranges in the "Years" columns in Table 2.1 begin with the year that the relevant enabling legislation was passed and end with the year that the last loan guarantee for a given program was finalized. Programs such as the Small Business Administration's 7(a) guarantee program are not included because advancing commercialization is not an explicit goal.

Table 2.1. First and Second Phase Loan Guarantee Programs Focused on Commercialization

Phase 1 Programs			Phase 2 Programs		
Program	**Administering Department**	**Years**	**Program**	**Administering Department**	**Years**
Geothermal (GLGP)	DOE	1974-1986	Section 1703	DOE	2005 - present
Electric and Hybrid Vehicles (EHV)	DOE	1976-1980	Biorefinery Assistance Program (BAP)	USDA	2008 - present
Biomass Pilot Plants	USDA	1977-1980	Section 1705	DOE	2009-2011
Alcohol Fuels	USDA	1980-1987			
Alcohol Fuels	DOE	1980-1987			

The criteria used in this paper to evaluate loan guarantee programs and projects focuses on two themes: 1) determining if the projects that received loan guarantees supported commercialization and 2) attempting to ascertain if the programs actually generated additional private lending that would not have occurred in the absence of a given loan guarantee program. Assessing the commercial status of a given energy technology is a relatively straightforward, although not unambiguous, process that seeks to answer two basic questions:

1) Which projects receiving loan guarantees were built and successfully operated?
2) Of the guarantee projects that have been completed and operated, which projects represent the deployment of technologies that have not yet reached commercial status in the US?

In order to answer the above two questions, two literature reviews were performed. The first literature review was used to identify past and present loan guarantee programs used to support energy technology commercialization, and to construct project histories for each identified program. The project histories were then used to identify which loan guarantee projects qualified as successful in terms of both construction and operation.

The second literature review focused on building an understanding of the commercial evolution of the technologies promoted by each of the loan guarantee programs identified by the first literature review. The loan guarantee projects identified as successful were then placed in context with the commercial evolution of the relevant technologies to determine if the loan guarantee programs actually contributed to commercialization.

Assessing which loan guarantee projects and programs contributed to the commercialization of a technology was precluded by the necessity of defining the point at which a technology reaches commercial status. This paper adopts the federal definition of a commercial technology given in the Code of Federal Regulations as "a technology in general use in the commercial marketplace in the United States". A "technology in general use" is further defined in the Code of Federal Regulations as a technology that "has been installed in three or more commercial projects in the United States in the same general application as in the proposed project, and has been in operation in each such commercial project for a period of at least five years" (10 CFR 609.2). Consequently, if a given loan guarantee project was preceded by three similar projects that have each been in operation for at least five years then it was not considered to support commercialization. The same rule was also used for the affirmative application; a loan guarantee supported project has to have operated for at least five years to be considered as meaningfully contributing to commercialization.

Unfortunately, using the reference for commercial technology provided by the Code of Federal Regulations does not provide any insight into what constitutes enough of a technological advancement to label a given technology as "new" in a commercial setting. The discussion presented in this paper assumes that only the introduction of technologies significantly different from those already in use qualify as "new" for assessing commercialization. For example, binary geothermal power plants are considered to be unique from dry steam geothermal plants for assessing commercialization while the installation of a more efficient heat exchanger in a binary plant is considered an evolutionary improvement. Although the assumption used in this paper to define what is a "new" technology is arguably restrictive, it does takes into account the increased degree of risk involved in situations for which there is limited to no previous design, construction, or operating experiences in comparison to situations for which there exists previous experience with the primary features of the technology in question.

Projects that have had their loan guarantees terminated but are able to continue through restructuring are treated as continuous loan guarantee projects in this paper. In general, when the holder of a federally guaranteed loan defaults, the loan is purchased by the guaranteeing agency and the lender is repaid the guaranteed portion of any outstanding principal and interest (Brooks and Cheew, 1984). Essentially, from a government and taxpayer perspective, most terminated loan guarantees become direct loans held by the guaranteeing agency. The loan guarantees reviewed for this paper have proved to be no exception. In every case of termination save one, the lender has been repaid and the outstanding debt taken over by the guaranteeing agency. Depending on project viability, the projects have been liquidated or had their loan terms restructured and continued operating with the guaranteeing agency as lender. It could be argued that once a guarantee is terminated, a project is no longer technically part of a loan guarantee program. However, given that the legislation and rulemaking governing loan guarantee programs specifically include provisions for managing default situations, this paper assumes that managing projects that have had their loan guarantees terminated is an inherent component of such programs.

The method employed to assess the possible creation of credit market additionality by loan guarantee programs focused on looking for information that supports the counterfactual. As mentioned in the introduction, proving the creation of additionality in credit markets is improbable due to the difficulty inherent in disproving the counterfactual. Therefore, this paper approaches assessing the likelihood of additionality by attempting to show that the counterfactual has indeed occurred. That assessment makes use of the information from the two previously described literature reviews to identify if similar projects that did not receive a loan guarantee were built and operated concurrently with projects that did receive loan guarantees. If similar non-loan guarantee projects were built concurrently with loan guarantee projects, it indicates that the loan guarantee program was not essential in channeling capital toward a desired technology. In such an instance it is possible that a program succeeded in creating adverse selection rather than generating credit additionality.

There are two major difficulties inherent in attempting to evaluate the impact of a policy on inducing additionality in credit markets. The first complication that arises is the inability to disprove the counterfactual that lending would have occurred anyway in the absence of a guarantee program. Since the event has been precluded from happening, it is impossible to measure (Vogel and Adams, 1997). A further complication is that all changes in lending behavior may not be attributable to the guarantee program (Vogel and Adams, 1997). For example, was a loan guarantee program instrumental in spurring lending to corn ethanol projects in the 1980s, or was the four cent per gallon excise tax credit a more influential incentive? Measuring additionality is also complicated by intra and inter-bank substitution. It is possible that a bank may reclassify existing applicants to fit into a loan guarantee program or that a bank participating in a guarantee program may simply be taking business from banks not participating in a program. If either form of substitution occurs, it limits or eliminates any additionality that may be generated by a loan guarantee program (Vogel and Adams, 1997).

The role of the Federal Financing Bank (FFB) in each program was also reviewed with the assumption that any project funded by the FFB cannot have contributed to additionality. The FFB is a bank housed inside of the Treasury that was created by Congress in 1973 to centralize the issuance of federal debt instruments in order to reduce costs and fees associated with debt issuance by individual federal agencies (Resler and Lang, 1979). Agencies that guarantee loans to non-federal borrowers can direct the FFB to provide a direct loan to the borrower instead of seeking private sector financing (Bickley, 1985). With energy commercialization loan guarantees, the FFB is used when the administering agency opts to guarantee 100% of a loan. When the FFB issues a loan guaranteed by a federal agency, the loan guarantee is converted into an off-budget direct federal loan to the borrower (Bickley, 1985). Because no private sector lender is involved in such a transaction, there is no direct way for additionality to be generated in private credit markets by the related guarantee.

While the methodology used in this paper can offer insights into the extent that loan guarantee programs have induced credit additionality in support of energy technology commercialization, it cannot provide quantitatively definite and irrefutable evidence. Although looking for information supporting the counterfactual provides an easier form for analysis than looking for direct irrefutable support of additionality, there are some drawbacks. Perhaps the largest limitation is that proving the counterfactual, that some lending would have occurred anyway, does not provide a complete refutation of lending additionality. Even if two projects use similar technology, there are a great many other factors that can contribute to borrower attractiveness from a lender's perspective. Such factors may include the experience of selected contractors, regional variations in market prices, and differences in funding structure (Yescombe, 2013)

3.0 Results

Table 3.1 lists the loan guarantee programs reviewed for this paper and outlines the types of technologies supported by each program as well as the number of loans guaranteed for each type of technology. For each supported technology, Table 3.1 also shows the number of projects that were successfully completed and operated and the number of completed projects that were assessed as contributing to the commercialization of a given technology. Only projects that operated commercially for five years or more are considered as being successfully completed and operated. The final two columns of Table 3.1 shows how many guarantee projects used private sector lenders (as opposed to the FFB) and the number of similar projects that were constructed concurrently with the guarantee program in question that did not receive federal loan guarantees. Projects that were judged to have supported technology commercialization, used a private sector lead lender, and had few to no similar non-guarantee projects constructed over the same time frame are viewed as projects that may provide evidence of the generation of credit market additionality in support of energy technology commercialization.

Table 3.1. Assessment of additionality in support of energy technology commercialization

Program	Technology Supported	LG Projects	Projects Completed, Operated	Projects Supporting Commercialization	Projects Using Private Sector Lenders	Similar Projects Constructed Concurrently
GLGP	Power Plants	5	2	1	4	3
	Agribusiness	2	2	2	2	0
	District Heating	1	1	0	1	13
EHV	Electric Vehicle Manufacturing	2	0	0	1	18
Biofuels Pilot Plants	Biofuels	1	0	0	1	0
USDA Alcohol Fuels	1st Generation Ethanol[1]	13	5	2	13	100+
DOE Alcohol Fuels	1st Generation Ethanol[1]	3	1	3	3	100+
DOE 1703	Nuclear Reactor	1	0	1	0	1
DOE 1705	2nd Gen Ethanol[2]	1	0	1	0	3
	Energy Storage	1	1	1	0	0
	Geothermal Plant	3	3	0	2	5
	Solar Manufacturing	3	0	3	0	0
	Solar HCPV	1	1	1	0	0
	Solar PV	5	4	0	0	7
	Solar Tower	2	1	2	0	0
	Solar Trough	3	1	0	1	0

	Transmission	1	1	0	0	10
	Wind Turbine	4	4	0	2	100+
BAP	2nd Gen Ethanol[2]	2	1	2	2	3
	Anaerobic Digester	1	1	1	1	2
	Algae-to-crude	1	0	1	1	0

1) 1st Generation ethanol facilities use corn, wheat, sorghum, sugar, etc. as feedstocks
2) 2nd Generation ethanol in this table refers to cellulosic ethanol

Table 3.2 summarizes the total number of guarantee receiving projects per program and the number of projects that may have simultaneously contributed to both credit market additionality and technology commercialization. From the first phase of loan guarantee programs, only the Geothermal Loan Guarantee Program and the USDA's Alcohol Fuels loan guarantee program sponsored projects that met the criteria for both commercialization and the potential to generate additionality. The Biorefinery Assistance Program is so far the only second phase loan guarantee program that has guaranteed loans to projects that meet this paper's screening criteria for commercialization and additionality.

Table 3.2.

Program	Number of Projects Supported to Date	Additionality & Commercialization
GLGP	8	3
EHV	2	0
Biofuels Pilot Plants	1	0
USDA Alcohol Fuels	13	2
DOE Alcohol Fuels	3	0
DOE 1703	1	0
DOE 1705	24	0
BAP	4	3
Total	**56**	**8**

4.0 First Phase Loan Guarantee Programs

4.1 DOE Geothermal Loan Guarantee Program

The Geothermal Loan Guarantee Program (GLGP) was enacted by Title II of the Geothermal Research, Development, and Demonstration Act of 1974 (P.L. 93-410) and was the first program of its type aimed at developing an energy resource (Nasr, 1978). The stated goals of the GLGP were to 1) accelerate the commercial development of geothermal resources and 2) develop normal lending relationships to enable debt financing in the absence of federal guarantees (Federal Register, 1976). The program guaranteed ten loans to eight projects that resulted in five defaults and three repayments (US Budget Notes and Appendices, 1991). Projects sponsored by the program included the exploration and development of geothermal fields, the construction of geothermal power plants, and the creation of direct use geothermal projects for district heating and agribusiness.

Table 4.1. Summary of GLGP projects

Project Name	Project Type	Outcome
Geothermal Food Processors	Vegetable dehydration	Defaulted 1978, loan and guarantee restructured in 1979, operating
Westmoreland	Field development	Defaulted Sept. 1984
CU-I*	Field development	Defaulted May 1984
NCPA #2	Dry steam plant	Loan repaid, operating
Boise Geothermal	District heating	Repaid, operating
Niland	Power plant	Defaulted July, 1985, Plant not built
Oregon Trail	Mushroom growing	Defaulted, restructured, operated until 2007
ORMESA I**	Binary plant	Loan repaid, operating

* Original guarantee for field development made to CUI on January 13, 1979 (GAO, 1980)

**Original guarantee for field development made to Republic Geothermal May 8, 1977 (GAO, 1980)

A major goal of the GLGP was to encourage commercial development of hydrothermal reservoirs because it was the only way for geothermal power production in the US to expand beyond the Geysers resource area (GAO, 1980). When the Geothermal Research, Development, and Demonstration Act was passed in 1974, the geothermal industry primarily consisted of dry steam power plants at The Geysers in California, the Boise Warm Springs Water District heating system in Idaho, and a few greenhouses (Geothermal Progress Monitor, 1985). Although the Geysers represents the largest geothermal electric field in the world, the majority of the useable geothermal reservoirs in the US are hydrothermal in nature and both the field and technology development needed to exploit those resources were in their infancy in the mid-1970's.

Five of the eight projects that received guarantees were related to geothermal field development and power plant construction. By the end of the program, two power plants had been constructed with the three remaining projects defaulting on their debt prior to plant completion (DOE OIG, 1987). The power plants that were completed were the NCPA #2 plant in the Geysers resource area and the ORMESA 1 project in the East Mesa resource area (Schochet and Mock, 1994). The NCPA #2 plant is a dry steam plant that was constructed in a well-known resource area in which similar plants had been producing electricity for nearly two decades and therefore represented little new in the way of industry advancement.

The development of hydrothermal resources for electricity production focused on flash and binary technologies. The three terminated loan guarantees that were focused on field development and power plant construction were all going to be the flash type of power plant. However, the absence of successful flash GLGP projects did not prevent the technology from being commercialized. Multiple flash plants were built concurrently with the GLGP and the technology continues to be used today. The obvious conclusion is that a loan guarantee program was not needed to commercialize geothermal flash technology in the United States. However, it should still be noted that other federal and state incentives were used to support the development and deployment of geothermal flash plants.

In contrast, the only hydrothermal project in the GLGP portfolio to achieve electricity production was the ORMESA 1 modular binary power plant. The ORMESA 1 plant consisted of 26 Ormat Energy Converters with a gross capacity of 30 MW (Schochet and Mock, 1994) and was the first large-scale commercial binary plant to achieve grid synchronization in the US. Several smaller binary plants achieved operation prior to the ORMESA 1 plant, most of which incorporated similar modular equipment supplied by Ormat. From the available literature and the size of the plants, it is difficult to determine which of the smaller plants were truly commercial in nature and which were initially designed as demonstration projects.

The ORMESA 1 project effectively had two guaranteed loan commitments during construction, a guaranteed construction loan by the Bankers Trust Company which was replaced by a guaranteed FFB long-term loan upon completion of construction. Closing the construction loan from Bankers Trust was predicated on ORMESA having a longer-term loan in place that would be used to pay off the construction loan once the facility was completed. The Teacher's Insurance and Annuity Association (TIAA) and John Hancock Insurance initially agreed to provide the long-term loan under DOE guarantee. In what appears to be a case of the FFB crowding out private investment, the ORMESA project allegedly backed out of the agreement with TIAA and John Hancock in favor of a lower interest loan from the FFB (TIAA v. ORMESA Geothermal, 1991). The guaranteed FFB loan was thus used to secure the guaranteed construction loan. While it could be argued that use of the FFB loan to secure the private loan negates any potential for additionality, it can also be argued that that there was potential for generating additionality directly through the guaranteed construction loan and indirectly through the FFB loan used to secure the construction loan. To be conservative, the results given in this paper assume the latter argument to be correct.

Of the three loans guaranteed for direct use applications, one of the guaranteed loans was repaid and the other two were defaulted on and subsequently restructured by DOE. The Boise Geothermal project was issued a guaranteed loan to expand a district heating system. Boise Geothermal avoided default; however, geothermal district and residential heating was already a commercial application at the time with two of the largest systems having begun production nearly a century earlier (Lund, 1987). The remaining two loans were for the construction of a vegetable drying plant at Brady Hot Springs in Nevada and a mushroom growing operation in Vale, Oregon. Both agribusiness projects defaulted on their loans, but were restructured and continued as viable enterprises for an extended period of time. Given that direct uses in agriculture at the time were largely limited to greenhouse operations and process heat in industrial facilities, it is likely that the two loans made for vegetable drying and mushroom growing contributed to the expansion of credit for funding direct use geothermal heat in agribusiness (Shaevitz and Rodzianko, 1979). This conclusion is supported by the fact that by the end of the 1980's the operations at Brady Hot Springs and Vale were the only two operating, commercial scale geothermal agribusiness facilities is the US (Lund, 1987).

4.2 DOE Electric and Hybrid Vehicles Loan Guarantee Program

The Electric and Hybrid Vehicle (EHV) loan guarantee program was created by the Electric and Hybrid Vehicle Research, Development, and Demonstration Act of 1976 (P.L. 94-413). The primary purpose of the EHV loan guarantee program was to facilitate small business involvement in the broader EHV research, development, and demonstration program by providing capital to encourage early commercial production of electric vehicles (EHV, 1977). A GAO report issued in 1979 succinctly summed up the barriers to electric vehicle commercialization as "they cost more and perform less than conventional vehicles" (GAO, 1979). The electric vehicles that were available at the time were slower, had limited range, and cost nearly twice as much as conventional vehicles, in addition to uncertain life-cycle costs. The same report noted that the loan guarantee program was likely premature given that commercial viability had not yet been demonstrated and that more research and development was needed (GAO, 1979).

The EHV program guaranteed loans to two companies, both of which defaulted and ceased operations. Jet Industries of Austin, Texas and Electric Vehicle Associates (EVA) of Cleveland, OH both received guarantees in 1980. Jet and EVA purchased vehicles chassis, called "gliders" from major car manufacturers and installed electric drive train components in the chassis. In the early 1980s Jet and EVA were responsible for 40% of the EV industry's total manufacturing capacity. However, both companies were heavily dependent on a related DOE demonstration program for sales, producing roughly 80% of the electric vehicles used by DOE's electric vehicle demonstration programs in 1981 (GAO, 1982).

Table 4.2. Summary of EHV projects

Project Name	Project Type	Outcome
EVA	EV Manufacturing	Defaulted, 1982
Jet Industries	EV Manufacturing	Defaulted 1982

Establishing a commercialization threshold for evaluating the EHV program differs somewhat from the criteria used for the other programs. For manufacturing, levels of production and sales are taken to be more important than the actual number of producing facilities. The Department of Energy had planned on reaching sales of 100,000 electric vehicles per year by 1988 at which time it was expected that the industry would be become self-sustaining and would no longer be dependent on government incentives (GAO, 1982). For comparison, roughly 15 million light motor vehicles were sold in the US in 1988 (BEA, 2014) so the DOE electric vehicle sales target would have accounted for about 0.7% of annual light vehicle sales. This paper adopts the 100,000 per year sales threshold as the commercialization point for evaluating the plug-in electric vehicle industry.

In 1980, there were roughly 20 small firms in the US producing less than 10,000 electric vehicles per year (Carriere et al, 1982). As of 2012 plug-in battery-electric vehicles in the US had yet to reach the 100,000 units per year in sales (ORNL, 2013). Given that commercialization had not yet occurred by the beginning of the 21st century, the potential existed for both EVA and Jet to contribute to the commercialization of plug-in electric vehicles. However, given that both projects operated for less than two years after receiving guaranteed loans, missed all but one of their production milestones, and relied heavily on government subsidized sales to a federal demonstration program, it would be difficult to argue that Jet and EVA accomplished anything other than proving the necessity of further technology R&D (GAO, 1982).

The companies involved were too small to effectively market the vehicles they produced and the technology was not sufficiently advanced to compete with conventional vehicles on price and performance. As stated by the GAO, “It is unlikely that any manufacturer needing a loan guarantee that is limited to $3 million dollars will play a major role in widespread EV commercialization” (GAO, 1982). Tellingly, DOE shifted the emphasis of the EHV program away from demonstration and mass production to focus on developing and testing technologies that had the features necessary to gain widespread acceptance of EHVs as a “practical transportation alternative”(EHV, 1982).

The loan to Jet Industries was provided by the FFB, making the guarantee on the EVA loan the only loan of interest for private sector credit additionality. A review of available literature failed to provide any evidence of commercial lending specifically for the purpose of supporting electric vehicle manufacturing in the absence of the loan guarantee program. This indicates that credit for small electric vehicle manufacturers may not have been available on reasonable terms for the time period in question. The conclusion is that the guaranteed loan made to EVA may be an instance of a guarantee program spurring additionality, but neither project had any real chance of providing meaningful support to the commercialization effort.

4.3 USDA Loan Guarantees for Industrial Hydrocarbons and Alcohol Fuels Pilot Plants

The USDA's Alcohol Fuels Pilot Plant Loan Guarantee Program was created by section 1420 of the Food and Agriculture Act of 1977 (P.L. 95-113) for the purpose of expanding markets for agricultural commodities and forest product and expanding the national supply of hydrocarbons. The program was to accomplish its purpose by providing loan guarantees to four pilot projects that would produce industrial hydrocarbons or alcohol fuels using the aforementioned agricultural commodities and forest products as feedstock (Food and Agriculture Act, 1977). Each guaranteed loan was not to exceed $15 million dollars, and the total energy content of the product was required to exceed the energy input derived from fossil fuels (Food and Agriculture Act, 1977).

The pilot program initially granted preliminary approval to four projects in 1979. However, only one loan guarantee was ever finalized. The guaranteed loan went to Guaranty Fuels of North Carolina Inc. for the construction of a plant that would convert forest and agricultural residues into fuel pellets (CCC Annual report, 1981; Spokesman Review, 1979). USDA's Commodity Credit Corporation (CCC) agreed with Wachovia Bank and Trust to provide a guarantee on a loan of roughly $4.5 million to Guaranty fuels on March 19, 1980. Guaranty defaulted on the loan on July 8, 1981 and subsequently filed for Chapter 11 bankruptcy protection (CCC Annual report, 1981). The land and equipment associated with the project were liquidated by the CCC a few years later (CCC Annual Report, 1984).

Table 4.3. Summary of USDA biomass pilot plant loan guarantee projects

Project Name	Project Type	Outcome
Guaranty Fuels	Biomass pellets	Defaulted 1981, liquidated

Since the Guaranty fuels project was never completed or operated, it did not have a chance to contribute toward commercialization. There is no evidence to suggest commercial lenders were financing similar projects at the time.

4.4 Alcohol Fuels Loan Guarantees

Title II of the Energy Security Act (ESA) of 1980 (P.L. 96-294) created two loan guarantee programs aimed at advancing the development of a biomass-based fuel alcohol industry in the US. Although the US federal government began working in earnest in the 1970s to incentivize the creation of a domestic alcohol fuels industry, by the beginning of 1980 that industry consisted of less than 10 plants producing roughly 25 million gallons of ethanol (Gavett et al, 1986). Early production was dominated by wet-mill facilities owned by companies such as Archer Daniels Midland (ADM), which added ethanol production to existing processing facilities to create new product streams while taking advantage of federal and state gasoline excise tax exemptions and other tax credits (Keeney, 2009). A large number of dry-mill facilities entered into production throughout 1980, but they were primarily small facilities with capacities of around one million gallons-per-year or less. In contrast, ADM's facility in Decatur, IL had an annual production capacity of over 50 million gallons-per-year (Gill and Dargan, 1982).

The two loan guarantee programs created by Title II of the ESA were divided between DOE and USDA. DOE was responsible for projects producing more than 15 million gallons-per-year of fuel ethanol and the USDA was to be responsible for providing guarantees to projects that produced less than 15 million gallons-per-year of fuel ethanol (Feldman et al., 1982). This paper assumes that wet-mill plants and dry-mill plants represent two different technologies for the purpose of assessing commercialization. The remainder of this section focuses on the commercialization of dry-mill ethanol plants, which were the only projects aided by the USDA and DOE loan guarantee programs. Wet-mill technology was commercialized prior to the construction of dry-mill ethanol plants.

4.4.1 USDA Loan Guarantees for Alcohol Fuels Production

Prior to passage of the ESA, USDA already had the ability to provide loan guarantees for alcohol fuels projects as authorized by the Rural Development Act of 1972 (P.L. 92-149). The Rural Development Act authorized USDA, via the Farmers Home Administration (FmHA) Business and Industry (B&I) program, to provide loan guarantees for on-farm, medium, and large scale plants. The ESA would have established a separate USDA office for guaranteeing loans to small and medium fuel ethanol plants. However, funding for the USDA ESA program was rescinded and a portion of the ESA funds reallocated to the existing B&I program (Feldman, 1982). The result was a USDA alcohol fuels commercialization assistance program that was administered via the B&I program; it guaranteed loans to 13 projects during the 1980s.

Table 4.4. Summary of USDA alcohol fuels loan guarantee projects

Project Name	Capacity (mgpy)	Outcome
Idaho Fuels	0.35	Defaulted, liquidated
Farm Fuel Products	2.3	Defaulted, liquidated
Boucher Rural Products	0.168	Defaulted, liquidated
American Fuel Tech	3.4	Defaulted, loan repaid
South Point Ethanol	60.0	Defaulted, restructured, operated until 1995
Carolina Alcohol	0.51	Defaulted, liquidated
Sepco, Inc.	0.80	Defaulted, liquidated
Coburn Enterprises	1.0	Defaulted, liquidated
Clinton-Southeast JV	3.0	Defaulted, liquidated
Kentucky Ag. Energy	21.0	Defaulted, restructured, operated until 1988
ADC-1	10.0	Sold at no loss, currently operating
Dawn Enterprises	10.0	Defaulted, restructured, operated until 2012
Alchem	4.0	Operated until 2007

Only 5 of the 13 projects that received loans guaranteed by the USDA are of interest from a commercialization standpoint. The remaining seven projects defaulted and closed without operating for any significant amount of time (Gavett et al., 1986). The South Point Ethanol and Kentucky Agricultural Energy plants both began limited operation in 1982 and likely aided in commercialization. South Point and Kentucky Agricultural were two of the first large dry-mill ethanol plants to enter into operation in the US, both facilities operated for more than five years, and details regarding the design and early operational history of both facilities were made publicly available (Jones, 1985). In addition, although there were roughly 10 corn ethanol plants already operating by 1982, none had been in business for more than a couple of years (Adams, 1982). Based on the methodology used in this paper, the technology had reached commercial status by the time the ADC-1, Dawn, and Alchem plants began operations.

Well over 100 fuel ethanol plants were built during the first half of the 1980s, implying the availability of financing on some scale. However, production was dominated by a handful of large plants which were either wet-mills capable of producing multiple product streams or dry mills backed by loan guarantees (Kane et al, 1989). The fact that the only large scale dry-mills built over the period were federally backed suggests that debt financing may not have been readily available for such facilities. Not only did the KAEC and South Point plants receive USDA loan guarantees, both projects were also backed by major oil companies (Herendeen and Reidenbach, 1982) and had entered into multimillion dollar cooperative agreements with DOE (Gavett et al., 1986). It is possible that such financing arrangements were needed in order to spread risk to a degree that was acceptable to project participants.

4.4.2 DOE Alcohol Fuels Loan Guarantee Program

By the time DOE guarantee authority for alcohol fuels plants expired in 1987, the Department had guaranteed loans for three large-scale production facilities being developed by the New Energy Company of Indiana, Tennnol Inc., and the Agrifuels Refining Corporation. All three companies defaulted on their loans and had their loan guarantees terminated. The New Energy loan was restructured and the facility was completed and operated with DOE as the prime lender. The Tennol and Agrifuels plants were both liquidated (Koplow, 2006). The New Energy Company plant falls outside the fuel ethanol commercialization window, but it is likely that the DOE loan guarantee represented additional lending to the industry given the absence of unassisted private sector lending to large-scale ethanol projects. By the end of the decade only three large scale dry-mill ethanol plants had been built in the US. One of those plants was owned by Archer Daniels Midland, while the remaining two plants (New Energy and South Point) had been backed by federal loan guarantees (Kane et al., 1989).

Table 4.5. Summary of DOE alcohol fuels loan guarantee projects

Project Name	Capacity (mgpy)	Outcome
New Energy Company	50	Defaulted, restructured, operated until 2012
Tennol	25	Defaulted, liquidated
Agrifuels	36	Defaulted, liquidated

5.0 Second Phase Loan Guarantee and Section 1703 Programs

5.1 DOE Title VXII Loan Guarantee Program

The Department of Energy's Loan Programs Office (LPO) oversees two loan guarantee programs that support clean and renewable energy projects. The two programs are the Section 1703 program which was authorized by Title VXII of the Energy Policy Act of 2005 (P.L. 109-58) and the Section 1705 program authorized by the American Recovery and Reinvestment Act of 2009 (P.L. 111-5). The LPO also oversees the Advanced Technology Vehicle Manufacturing Program, which is a direct loan program rather than a loan guarantee program (Independent Consultant's Review, 2012). The Title 17 Loan Guarantee Program was created for the purpose of guaranteeing loans for projects using "new or significantly improved" technologies that "avoid, reduce, or sequester air pollutants or anthropogenic emissions of greenhouse gasses" (Energy Policy Act, 2005). More succinctly, the program aim is to finance new technologies that have a high probability of being commercially successful and that are environmentally beneficial (Massouh and Cannon, 2009).

DOE's Title 17 program differs from previous loan guarantee programs aimed at energy technology commercialization in that it sponsors a variety of technologies and has no sunset clause. The program operates by issuing solicitations for specific technologies, with the first solicitation issued in August of 2006 for pre-applications for a mix of eligible projects (Massouh and Cannon, 2009). The Title 17 program was temporarily expanded by the American Recovery and Investment Act of 2009 to include shovel ready renewable energy and transmission projects (Massouh and Cannon, 2009). The Section 1705 program had a built-in sunset clause that required guaranteed projects to begin construction by September 30, 2011 (Independent Consultant's Review, 2012). The Section 1705 program also differed in that it was limited to fewer technology categories than the original Section 1703 program (Kao, 2013).

5.1.1 The Section 1703 Program

The first, and so far only, loan guarantees made under section 1703 authority were not finalized until February 20, 2014. The two guarantees were made to assist in the expansion of the Vogtle nuclear plant via the addition of two new nuclear reactors (Mirshak, 2014). While the two reactors being built at Vogtle could be considered as supporting the commercialization of a new generation of nuclear technology, the guaranteed loans do nothing to spur additionality in the private credit markets. The guarantee recipients, Georgia Power and Oglethorpe Power, were already financing construction of the plants via private markets and had stated their intent to construct the new reactors with or without the loan guarantees (Platts, 2014). In addition, funds for the guaranteed loans are being provided by the Federal Financing Bank (Oglethorpe 8-k, 2014 and Southern Company 8-k, 2014) which means the agreement may actually reduce private sector credit participation in the project.

Table 5.1. Summary of Section 1703 loan guarantees

Project Name	Recipient	Status
Vogtle Units 3 & 4	Georgia Power	Under construction
Vogtle Units 3 & 4	Oglethorpe Power	Under construction

5.1.2 The Section 1705 Program

The Section 1705 program provided guarantees for 24 projects before its guarantee authority expired at the end of September 2011. Those 24 projects were guaranteed as a response to five different solicitations issued by both the 1703 and 1705 programs. Using the methodology presented in this paper to analyze the impact of the 1705 program on commercialization and additionality is a fairly simple exercise for two reasons: 1) the majority of the guaranteed loans were funded by the FFB and 2) loans that were not funded by the FFB were the result of a solicitation called the Financial Institute Partnership Plan (FIPP) that explicitly required projects to use commercial technology. Therefore, not a single project receiving a guarantee under 1705 authority could simultaneously support commercialization and the generation of additionality in private credit markets. The 24 projects guaranteed by the 1705 program are summarized in Table 4.3 along with notes as to technology commercialization requirements, lender status, and current project status.

Table 5.2. Summary of Section 1705 loan guarantee projects

Project Name	Project Type	New and Innovative Requirement?	Lead Lender	Status
1366 Technologies, Inc	Solar Mnf	Yes	FFB	Planning
Abengoa Biomass	2nd Gen Ethanol	Yes	FFB	Under Construction
Abengoa Mojave	Solar Trough	Yes	FFB	Under Construction
Abengoa Solana	Solar Trough	Yes	FFB	Operating
Abound Solar	Solar Mnf	Yes	FFB	Defaulted
Shepherds Flat	Wind	No	Private	Operating
Cogentrix Alamosa	Solar HCPV	Yes	FFB	Operating
Exelon Antelope Valley	Solar PV	Yes	FFB	Operating
Granite Reliable Wind	Wind	No	Private	Operating
Kahuku wind	Wind	Yes	FFB	Operating
LS Power ON line	Transmission	No	FFB	Operating
Mesquite Solar 1	Solar PV	Yes	FFB	Operating
Blue Mountain	Geothermal	No	Private	Operating
Nextera Desert Sun	Solar PV	No	Private	Under Construction
Nextera Genesis	Solar Trough	No	Private	Under Construction
NRG Brightsource	Power Tower	Yes	FFB	Operating
NRG California Valley	Solar PV	Yes	FFB	Operating
NRG Agua Caliente	Solar PV	Yes	FFB	Operating
Ormat Nevada	Geothermal	No	Private	Operating
Record Hill wind	Wind	Yes	FFB	Operating

Crescent Dunes	Power Tower	Yes	FFB	Under Construction
Solyndra, Inc.	Solar Mnf	Yes	FFB	Defaulted
Beacon Power	Flywheel Storage	Yes	FFB	Defaulted, operating
US Geothermal	Geothermal	Yes	FFB	Operating

It is not surprising that the 1705 program did little, if anything, to spur additional lending in support of commercialization. The program was authorized as part of the ARRA, which was a countercyclical stimulus bill passed to aid economic recovery from the recent recession (Leeper et al., 2010). As part of the stimulus package, the 1705 program ideally needed to promote lending in a timely, targeted, and temporary manner (Summers, 2008). The use of the FFB as lender may have served to expedite project financing by eliminating the need for project developers to secure a lead lender, and the need for the lead lender to establish a lending consortium with other institution. The FIPP solicitation, which required project technology to be commercial in nature, may have also served to speed lending and project construction.

5.2 USDA Biorefinery Assistance Loan Guarantee Program

The Biorefinery Assistance Program (BAP) was created by Section 9003 of the 2008 farm bill (P.L. 110-234) to provide loan guarantees for the construction or retrofitting of biorefineries and for the purpose of demonstrating the commercial viability of advanced biofuels production (Schnepf, 2013). A brief summary of the status of the program is presented in Table 4.4. Commercial production of cellulosic biofuels and other products produced from non-corn based biorefineries is in its infancy in the US. The Biorefinery assistance program has the potential to contribute to the commercialization of advanced biofuels and bio-products if the projects that have already received finalized loan guarantees and conditional commitments are successful in reaching operational status and maintaining steady operation for several years.

Table 5.3 Summary of Biorefinery Assistance Program loan guarantee projects

Project Name	**Project Type**	**Status**
Range Fuels	Cellulosic Ethanol	Defaulted in 2011, sold to LanzaTech in 2012
Sapphire Energy	Algae-to-crude oil	Repaid loan in 2013, operating at demo scale
Fremont CD	Anaerobic Digester	Operating
INEOS-BIO	Cellulosic Ethanol	Operating

The INEOS-BIO project has only recently begun operations and may soon be one of the first commercial scale cellulosic ethanol producers in the US. The plant converts municipal vegetative waste into ethanol. The Range Fuels plant could have preceded the INEOS project in producing cellulosic ethanol, but the plant defaulted on its guaranteed loans after failing to operate as intended (Herndon, 2012). The Fremont plant is a waste digester that began operations in the fall of 2012 and is currently operating.

Sapphire Energy repaid its USDA-backed loan using private equity funding and is currently operating as a demonstration facility with plans to expand to full commercial production over the next several years. The INEOS, Sapphire, and Fremont facilities all have the capacity to aid in commercialization and may represent additionality in credit markets given the small number of comparable facilities built over the same time period.

Conclusion

The work presented in this paper has focused on identifying projects supported by federal loan guarantees that may have aided in generating additional private sector lending in support of the commercialization of clean and renewable energy technologies. Multiple different programs attempting to advance the commercialization of such technologies have operated periodically since the mid-1970s. To date, those programs have provided financial assistance to 56 different projects with only eight of those projects identified as likely to have simultaneously supported private credit market additionality and technology commercialization.   Of those eight loan guarantees, three supported geothermal technologies and the remaining five were committed to biofuels projects.

Many of the guarantee projects reviewed for this paper were unable to make major contributions to commercialization because they failed to reach startup, operated for a short period of time, or the underlying primary technology had already reached commercial status. Two small programs from the first phase of guarantees were complete flops while larger programs aimed at commercializing new geothermal technologies and the production of first generation biofuels each achieved some measure of success. However, those commercialization advances came at a cost to the taxpayer ranging in the tens to hundreds of millions of nominal dollars depending on the program in question. Current loan guarantee programs operated by the USDA and DOE have the potential to aid in advancing the commercialization of some technologies, particularly the production of cellulosic ethanol. However, the extent of that advancement will not be known for several years and both programs have already suffered guarantee terminations.

Definitively determining if, and the extent to which, loan guarantee programs are responsible for generating additional lending is exceedingly difficult. This paper assumes that proving such additionality is unrealistic for the class of programs under study and instead used the more effective approach of examining the counterfactual for each project and program on a technology basis. In the majority of cases where it was determined that there is little information to support the counterfactual, the guarantee projects in question were generally significantly larger than similar existing and concurrent projects, and were some of the very first projects built using the primary technology in question.   It is not surprising that larger guarantee projects had fewer non-guarantee analogues. While projects involved in the early stage deployment of a given energy technology may both share similar operational and market risks, larger projects will generally require putting more capital at risk and raising that capital is more likely to require access to credit markets.

The goal of this paper has been to identify projects that are the best candidates for further study of the benefits of energy commercialization loan guarantee programs. The primary aim of such programs is to advance the commercialization timeline of the technologies sponsored by a given program. However, it is unclear to what extent the programs have actually advanced commercialization timelines and how such advancements should be quantified in terms of their benefit to society. Related information on administrative and defaults costs is, in most cases, already publicly available. The programs that have supported, or are currently supporting, the eight projects identified in this study may provide the best starting point for attempting to describe the commercialization benefit of a loan guarantee program in terms of monetary value or another comparable metric. That benefit measure can then potentially be combined with available cost data to produce a study of the costs and benefits of energy commercialization loan guarantee programs that is more thorough than the analyses currently available. Ideally, such a study could contribute to more informed discussions regarding the costs and benefits of federal energy technology commercialization loan guarantee programs.

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