MARCH
2019

policy matters

california senate OFFICE OF RESEARCH

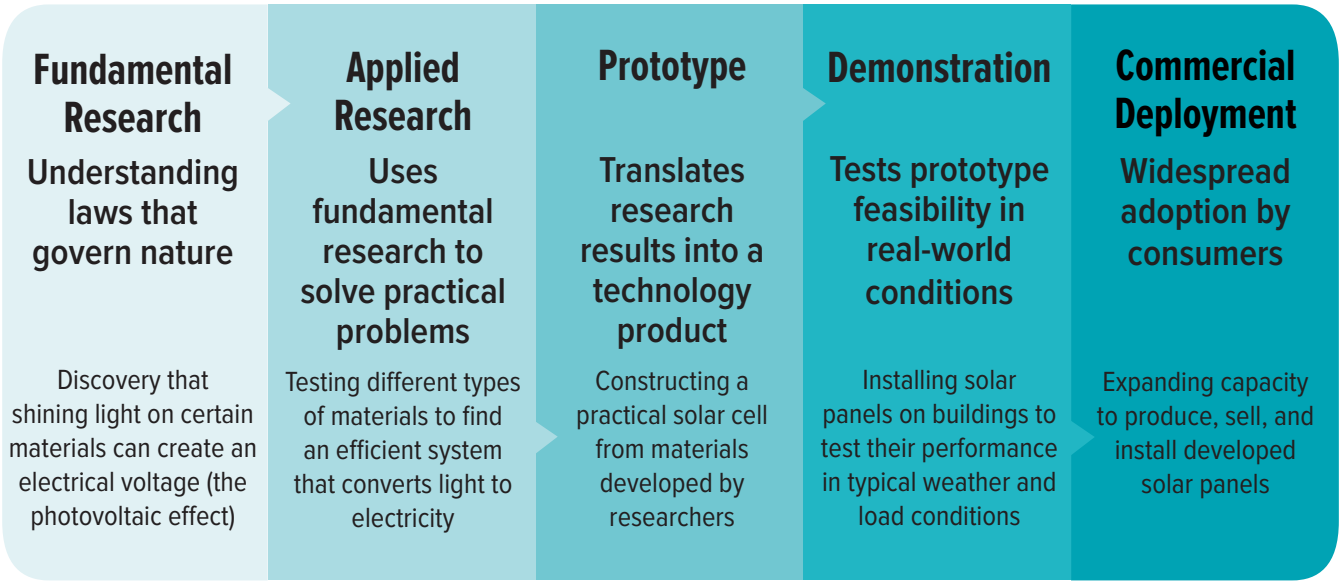
STATE INVESTMENTS IN CLEAN ENERGY AND TRANSPORTATION TECHNOLOGY

California has been at the forefront of efforts to reduce both global and local air pollution and transition to a clean energy economy. SB 32 (Pavley), Chapter 249, Statutes of 2016, established a target of reducing greenhouse gas emissions by at least 40 percent below 1990 levels by 2030. SB 100 (de León), Chapter 312, Statutes of 2018, recently established a renewables portfolio standard requiring at least 60 percent of retail electricity sales to be procured from eligible renewable energy resources by 2030. AB 617 (C. Garcia), Chapter 136, Statutes of 2017, intends to address some of the state's worst air pollution problems by requiring local air districts to implement a community emissions reduction program and the best retrofit control technology for air pollution.

Technological breakthroughs may be necessary to cost effectively reach many of the state's leading environmental, energy, and climate change goals. For example, current energy efficiency technologies are unlikely to be widely adopted in sectors that present the greatest opportunities for energy savings.[1] According to the California Air Resources Board (ARB), "achieving California's climate and clean air goals will require an ongoing transformation of the transportation sector—in both the light-duty and heavy-duty vocations—to the use of zero-emission technologies wherever feasible and near zero-emission technologies with the cleanest, lowest carbon fuels everywhere else."[2] The Legislature has helped foster technology development through regulatory policies and financial assistance.

This report describes the state's investments in clean energy and transportation technology development through 40 existing financial incentive programs. Budgetary and other information on the programs reviewed in the report is presented in the appendix. The report also discusses the pipeline of clean technology development, including challenges faced at each phase. Finally, the report presents what we believe are important considerations for the Legislature. To further assess the issues, the Legislature may consider creating an expert panel to address

FIGURE 1
Clean Technology Development Pipeline



balancing investment levels along the pipeline, reducing redundancies, and identifying strategies to leverage private investment.

CLEAN TECHNOLOGY DEVELOPMENT PIPELINE

Development of new technology occurs across several stages. When considering how best to support clean technological breakthroughs, it is important to understand the nature of the pipeline and the challenges faced at each stage of development. In this report, the pipeline is shown as having five main stages: fundamental research, applied research, prototype, demonstration, and commercial deployment (see Figure 1 above). In reality, technology does not develop along a linear path; there are many feedback loops to and from different parts of the pipeline. However, the model used in this report is useful as a tool for placing technology at a particular point in development.

The five stages are defined in more detail below. Note that the distinctions represent broad characterizations of the essential steps in technology development, and it is possible to break the sections into more nuanced categories. For example, many researchers and entrepreneurs utilize a rating system developed by NASA that consists of nine technology readiness levels to assess the maturity of a particular piece of technology.[3] In addition, specialists in different fields may use similar terminology to describe different segments of the pipeline. Terms such as market facilitation, the commercialization arc, technology development, and demonstration may be used by different program administrators to describe different segments of the pipeline.

Fundamental Research

Fundamental research consists of the pursuit of knowledge of the fundamental laws that govern nature. For example, the technology that allows rooftop solar panels to work has its roots in an experiment performed by Edmond Becquerel, in which he discovered that shining light on certain materials could create an electrical voltage (named the photovoltaic effect). While Becquerel made his discovery in 1839, it would be more than 100 years before the first practical solar cell was developed.

While technology development timelines have improved significantly, the generally long time frame between fundamental research and its real-world application creates challenges for securing funding

for fundamental research. Although investing in fundamental research can yield widespread public benefit, it is difficult to link the public benefits to specific investments.[4] The majority of fundamental research in the United States is conducted at universities and colleges and is supported primarily by the federal government and universities. In 2015, fundamental research spending in the United States totaled about $83.5 billion, with 44 percent coming from the federal government.[5] The state currently does not invest in supporting clean energy or transportation at the fundamental research stage.

Applied Research

Applied research seeks to use the results of fundamental research to solve practical problems. While fundamental research concerns itself with the general pursuit of knowledge, applied research typically focuses on finding solutions to a specific problem. In our solar panel example, this stage might consist of testing different types of materials and configurations to find a system that converts light to electricity at a desired level of efficiency.

While the solutions-oriented nature of applied research may make it a more attractive candidate for investment, the timeline for bringing energy technology at this stage to market is likely still 10 years out.[6] Research programs administered by the California Energy Commission (CEC) are examples of state programs that invest in clean technology at the applied research stage.

Prototype

The prototype stage focuses on developing procedures and products that will be the basis for the final form of the technology. Sometimes called development research, this stage aims to translate the results of fundamental and applied research into a product that eventually could be brought into the market. While early research typically is confined to universities and labs, the prototype stage extends into the entrepreneurial space, and development of the technological product often occurs alongside development of a business to support the product. Returning to our example of solar panels, this stage would focus on developing a start-up company with the goal of constructing a practical solar cell from a new configuration of materials developed by researchers.

There is a financial and cultural gap between innovations that take place in laboratory settings and the companies that eventually will develop the technology commercially, and bridging the gap is vital for the continued development of the technology. While funding is an issue across all early stages of the development pipeline, lack of capital is a particularly significant barrier in the prototype stage. With most federal research money directed at fundamental and applied research, prototype development is funded largely through private venture capital (VC). However, while VC firms tend to operate on investment timelines of three to five years, the average length of time from founding to initial public offering on clean energy technology start-ups is 8.3 years.[7] VC interest in clean energy technology peaked in the mid-2000s, but investments dropped after the 2008 financial recession, primarily due to high capital requirements, long development timelines, and relatively low returns. Ultimately, the software and medical technology sectors offered investors more reliable and quicker returns.[8] Finally, the presence of "knowledge spillover"—the idea that major technology breakthroughs eventually disseminate across an entire industry sector—may discourage companies from investing in research and development if they believe they

eventually will be able to benefit from discoveries made by others.[9]

Further complicating the unfavorable returns on clean technology investments are issues related to intellectual property (IP) rights. IPs are products resulting from research discovery that are protected by law, such as copyrights, trademarks, and patents. Another recent analysis from our office found that inconsistent or unclear state IP stewardship policies can discourage private investment by undermining a VC's competitive advantage to developing a new technology.[10] A recent example of this was revealed in 2016, when CEC conducted a survey of its Electric Program Investment Charge (EPIC) grant recipients and found many entrepreneurs and private investors did not apply to the program over concerns about EPIC's IP policy.[11] CEC reports this issue has been partly resolved by clarifying some of EPIC's IP policy language.

The prototype stage also introduces nonfinancial barriers to development. The skill set of successful researchers does not necessarily overlap with the skills required to be successful in the entrepreneurial space. Even when technology moves to the prototype stage, newly formed start-up companies may still struggle with lack of access to facilities and support services, and unfamiliarity with key business operational principles and inexperience in the energy or transportation ecosystem can further impede progress.[12]

CEC's EPIC is one example of the state supporting clean energy technology at the prototype stage. In 2016, EPIC created a subprogram, California Sustainable Energy Entrepreneur Development (CalSEED), that specifically supports developing clean energy prototypes. CEC approved $25 million in five-year grants that provide $150,000 to support the conceptual development of a prototype and $450,000 to support its actual development. CalSEED is one initiative within EPIC's larger strategy to create an energy innovation ecosystem to support the early commercialization of clean energy technology. As part of this effort, EPIC also created four regional innovation clusters around the state to support certain grant award winners by providing access to lab facilities, mentors, and educational resources, among other things. EPIC recently granted each regional cluster $5 million to provide these services.

Demonstration

The goal of a demonstration project is to provide developers, investors, and potential customers with information about the cost, performance, safety, and reliability of the technology when used in a typical operational setting. In this stage, technology transitions from the small-scale, controlled setting of a prototype to the larger scale necessary for commercial deployment, allowing developers to address problems that arise from operating in real-world conditions. Additionally, the manufacturing procedures required to eventually bring a product to market may introduce engineering problems not present at the prototype scale that must be addressed before full market deployment. Taking our solar company example further, at this point the company has manufactured a solar panel that incorporates its breakthrough technology and is installing the panels on buildings to test their performance in typical weather and load conditions.

The demonstration stage invites a different set of challenges in technology development. Siting large installations requires negotiating with local jurisdictions, complying with regulations, and acquiring the appropriate permits, all of which can delay or halt projects. Demonstration projects also must incorporate other downstream actors, such as contractors, technicians, and end users, potentially adding further complications to their completion. Furthermore, deploying clean technology often relies on other existing technologies, and incorporating the new technology into the existing infrastructure can create operational and regulatory issues (such as managing utility interconnection agreements when deploying new energy technology). Finally, demonstration projects, particularly in the clean energy and transportation technology space, often require such large amounts of capital to implement that they can become infeasible. Support for demonstration projects relies on a unique type of investor, one that falls somewhere between those that traditionally support prototypes and those that support deployment. Traditional VC funds are not structured to make investments on this scale, and traditional finance investors, while possessing the resources to fund the projects, often are averse to the risk associated with these technologies.[13]

The state has a handful of financial incentive programs that support clean energy and transportation technology at the demonstration stage, the largest of which is EPIC. In January 2019, CEC approved EPIC's new CalTestBed project, which intends to provide prototype developers with access to test bed facilities to accelerate their transition to field demonstrations.

Commercial Deployment

The final stage of technology development is commercial deployment: getting the new technology onto the market and into the hands of the desired user. This stage can be further divided in two parts: deployment on the supply side (e.g., expanding manufacturing capacity to produce solar panels on the commercial scale), and the demand side (the sale and installation of solar panels).

The primary barriers to commercial deployment are the market realities of the technology landscape. Refining a feasible path to market should be a major part of development up to this point, and identifying early adopters and potential beachhead markets (i.e., smaller market segments to focus on developing before entering the wider commercial market) can ease the deployment process immensely. Beyond that, full commercial deployment brings the added investment challenge of funding the scaling up of manufacturing capacity and support infrastructure. However, if existing alternatives to new technology are cheaper, widespread adoption will be difficult without improvements in cost effectiveness.

The vast majority of state financial incentive programs that support clean energy and transportation technology development are in the commercial deployment stage. One example of a state program that supports the supply side of commercial deployment is a sales tax exemption program for certain manufacturers administered by the California Alternative Energy and Advanced Transportation Financing Authority (CAEATFA). This program specifically targets manufacturers of alternative energy and advanced transportation technologies to promote their consumer adoption.

STATE PROGRAMS SUPPORTING CLEAN ENERGY AND TRANSPORTATION TECHNOLOGY DEVELOPMENT

Supporting Technology Development

Experts typically classify support for clean technology development as functioning as either pushing or pulling the technology through the pipeline. Supporting the segments of the pipeline from the fundamental research through first demonstration stages generally is seen as pushing the technology through the pipeline, while supporting commercial deployment efforts is considered to have a pulling effect. Strategies that push technology through the pipeline can be more expensive and risky in the short term but are likely to have more significant long-term impacts by fostering technology breakthroughs. In contrast, pulling strategies can provide near-term benefits with less risk and lower costs but are also less likely to significantly impact the technology

landscape. While pulling strategies may do more in the short term to deploy clean technology, their impacts typically are limited to within the state. Technological breakthroughs that result in more efficient and cost-effective clean technologies have the added benefit of penetrating jurisdictions beyond the state, potentially having a greater effect on global environmental goals.

Both regulatory policies and financial investments can support movement through the technology development pipeline. Generally, regulatory policies such as SB 100 intend to create a market signal to pull new technologies through the pipeline. Some financial incentives for commercial deployment act to support and complement regulatory policies, primarily by reducing the economic costs of market adoption. Other financial incentives that support earlier innovation could lead to establishing new regulations once the new technology is proven to be feasible.

Both pushing and pulling policies and programs have proven to be effective for clean technology development, but experts recommend they be optimally balanced.[14] Overinvestment in massive commercial deployment of inefficient technologies could lead to very expensive pathways to achieving environmental and climate change goals. For example, one analysis of public expenditures supporting renewable energy technologies in the European Union (EU) member states showed they likely overspent in their commercial deployment pulling investments, compared with their pushing investments in research and demonstration.[15] The study's authors recommend increasing public EU investments in the earlier stages of the technology development pipeline, leading to a less costly energy transition in the long run.[16]

Some state agencies that provide financial incentives across different segments of the clean technology pipeline develop frameworks and plans to guide and balance their investments. For example, SB 1204 (Lara), Chapter 524, Statutes of 2014, which created a technology program intended to help support the development and deployment of cleaner heavy-duty vehicles and engines, requires ARB to coordinate with CEC to develop an annual framework and plan to guide investments that support the technologies.[17] In 2018, ARB developed the first three-year investment strategy that describes its overarching vision for using financial incentives primarily to support the commercial deployment and some demonstrations of clean transportation technology.[18] The triennial investment plan created by CEC for EPIC is another example of this planning. EPIC's investment planning is among the most comprehensive in the state as it invests in supporting clean energy technology in the applied research, prototype, demonstration, and commercial deployment segments of the pipeline.

Financial Incentives Used to Support Technology Development

Public investment in the technology pipeline can take a number of forms. California utilizes a wide variety of financial incentives to support its development, ranging from direct payments to individuals purchasing specific technology to more complex financing mechanisms to provide assistance on large-scale infrastructure projects.

Tax Incentives typically come in one of two forms: credits and deductions. Credits offer a reduction in the amount of tax owed and can be either refundable or nonrefundable. If the value of a refundable tax credit exceeds the amount of tax liability, the taxpayer receives the difference back as a refund. An example of a tax credit offered by the state is the research tax credit administered by the Franchise Tax Board, which provides a credit for qualifying research performed within the state. In contrast, a tax deduction reduces the amount of money subject to a particular tax, such as income or property tax. The sales tax exclusion for manufacturers program administered by CAEATFA offers an exemption from sales tax on qualified purchases by manufacturers that promote alternative energy and advanced transportation.

Grants are funding provided for a specific project or purpose that does not require repayment. Grants typically come with some level of reporting requirements and usually are offered through a competitive solicitation, where potential grantees submit proposals to the granting body. Grants are one of the main tools that governments have at their disposal to fund scientific research, such as the grants offered through EPIC.

Direct Payments allow California to offer money to individuals or companies for certain behaviors deemed beneficial to the state and the public, such as the purchase of clean technology. Direct payments can be in the form of vouchers, which provide a discount on the purchase of a particular item, or rebates, which provide some money back after such a purchase. California offers rebates for the purchase of zero-emission and plug-in hybrid light-duty vehicles through the Clean Vehicle Rebate Project.

Loan Programs allow the state to finance projects that struggle to attract private investment due to perceived risks in the market. This can take the form of direct loans offered by the state, often with better interest rates or more flexible terms than private counterparts, or credit enhancements, which aim to make private financing a more attractive prospect to investors. In terms of direct loans, clean energy projects are often financed through revolving loan funds, such as the California Lending for Energy and Environmental Needs Center within the California Infrastructure and Economic Development Bank. A revolving loan fund is a pool of capital, often sustained through interest payments and lending fees, from which loans are made for a particular purpose. The loans are repaid back into the fund, giving it its "revolving" name. As long as there are few defaults on such loans, a revolving loan fund can sustain itself indefinitely.

On-Bill Financing (OBF) and Property Assessed Clean Energy (PACE) loans are similar methods of financing that allow property owners to invest in clean technology upgrades to their property while deferring the high upfront capital costs associated with such investments. A lender will provide the upfront costs for the upgrade, and the property owner repays the lender through payments on their bills or property taxes. In programs such as California's Investor Owned Utilities (IOU) Energy Efficiency OBF Program, the utility supplies the initial capital to fund energy-efficiency upgrades, which is repaid on the customers' utility bills. With PACE, third-party lenders like banks provide the initial loan to install clean energy technology such as rooftop solar or other energy efficiency upgrades. Property owners repay the loans on their property tax bills via new tax liens on the structure. The relevant tax-collecting agency then collects the loan repayments and transfers the funds to the lender. PACE programs can focus on both residential (often called R–PACE) and commercial (C–PACE) properties.

Credit enhancements are tools that can be used to improve the chances that financing will be repaid and make lending more attractive for private investors. While many mechanisms can be used as credit enhancements, two of the most common are loan loss reserves and loan guarantees. A loan loss reserve, such as the PACE loan loss reserve administered by CAEATFA, sets aside a certain amount of money to cover a portion of a lender's losses in the event they cannot secure repayment. Similarly, a loan guarantee assures lenders that the government entity issuing the guarantee will assume the debt of a borrower in the event they default.

Other types of credit enhancements include interest rate buy downs or subordinated debt structures.

In an interest buy down, the state can use public funds to lower the interest rate a potential borrower would incur by paying the lender upfront, to such a point that private financing becomes a feasible option. Alternatively, the state can enter into loan agreements with two sources of capital, a subordinated (typically a smaller share of the total value of the loan) and a senior source. In the event of a default, the senior capital incurs no losses until the subordinated capital is fully exhausted. In this way, while the subordinated capital contributes less to the total value of the loan, it takes on a greater portion of the risk.

Ultimately, credit enhancements serve as a mechanism for the state to assume a certain amount of risk inherent in technology financing, facilitating private investors to enter the market.

STATE PROGRAMS PROVIDING FINANCIAL INCENTIVES FOR TECHNOLOGY DEVELOPMENT

The appendix contains a list of 40 existing state financial incentive programs that primarily support clean energy or transportation technologies. The appendix contains the following information for each program:

- Program name
- Program description
- Fiscal year (FY) 2018–19 funding level
- Cumulative funding received through FY 2018–19
- Location on technology development pipeline
- Name of program administrator (to whom a consumer would apply for funding)
- Name of the lead agency (who controls the funds)
- Technology category (renewable energy, energy efficiency, or clean transportation)
- Type of financial incentive

Table 1 below shows the estimated FY 2018–19 combined funding level for the 40 programs according to where they are on the technology development pipeline. A handful of programs cross over between technology categories and/or between segments on the pipeline. For example, EPIC targets renewable energy and energy efficiency technologies, and comprehensively spans the technology development pipeline from applied research through commercial deployment. For programs that overlap on the technology development pipeline, funding levels for each segment have been estimated by consultation with the administrating agencies. Funding levels have been split evenly for most of the programs that cross technology categories.

To provide a broader overview of state investments and clean technology, Table 2 on page 9 shows the estimated cumulative combined funding levels for the 40 existing programs through FY 2018–19. Please note that Table 2 includes only programs that are currently funded for FY 2018–19 and does not

Table 1
Estimated FY 2018–19 Funding Levels for State Programs Supporting Clean Energy and Transportation Technology ($ in Millions)

Technology Category	Fundamental Research	Applied Research	Prototype	Demonstration	Commercial Deployment
Renewable Energy	$0	$20	$20	$90	$420
Energy Efficiency	$0	$20	$20	$80	$930
Clean Transportation	$0	<$2	<$2	$50	$1,080

Table 2
Estimated Cumulative Funding Levels through FY 2018–19 for Existing State Programs Supporting Clean Energy and Transportation Technology ($ in Millions)

Technology Category	Fundamental Research	Applied Research	Prototype	Demonstration	Commercial Deployment
Renewable Energy	$0	$100	$100	$500	$4,000
Energy Efficiency	$0	$100	$100	$400	$13,300
Clean Transportation	$0	<$20	<$20	$300	$6,300

include previous state investments for programs that are no longer active.

FINDINGS

State Investments in Clean Technology Focused on Commercial Deployment

Both Table 1 and Table 2 show that state investments in clean energy and transportation technology are primarily in the commercial deployment stage of development, where the programs have a pulling influence on moving technology through the pipeline.

Program Overlap

We also found apparent overlap among some of the 40 programs listed in the appendix. Programs targeting commercial deployment of energy-efficiency technologies appear to have the most potential overlap. The programs include the PACE Loss Reserve, Low-Income Weatherization and Solar, California Hub for Energy Efficiency Financing Pilot, IOU Energy Efficiency, and IOU On-Bill Financing programs. Additionally, numerous financing programs appear to target heavy-duty vehicles, electric vehicle infrastructure, and low-income consumers. Program overlap is an important area to explore because duplication of efforts can lead to inefficiencies and difficulty in coordination across the administering entities and create confusion for consumers interested in receiving funding.[19]

The potential for overlapping programs could be greater than we have identified in this report. The appendix lists only state programs that specifically target clean energy or transportation technologies, but overlap with other state financial incentive programs that do not specifically target these technologies also is likely. For example, the Legislative Analyst's Office found the sales tax exemption program for certain manufacturers administered by CAEATFA is unnecessary because it overlaps heavily with another, broader partial state sales tax exemption.[20] There also is potential for state program overlap with federal and local programs not reviewed in this report.

NEXT STEPS

Consider Forming an Expert Advisory Panel

Having identified and compiled information for 40 state programs supporting clean energy and transportation technologies, we find a need for a holistic review of state investments across the technology development pipeline. Such a review is warranted for two main reasons: First is to remove any potential redundancies and promote cross-agency collaboration. Numerous and potentially overlapping programs could lead to several challenges, such as negative interaction with other policies, difficulties in evaluating programs, potential

lack of coordination, and increased administrative costs.[21] Second is to help guide strategic investments to ensure the state achieves a balanced investment portfolio and optimally leverages private capital to address market failures. Achieving a balanced investment portfolio will help ensure that inefficient technologies are not deployed to achieve the state's climate and environmental goals.

Each of the technology areas reviewed in this report—renewable energy, energy efficiency, and clean transportation—typically require specialized expertise that does not necessarily translate to other technology areas. Additionally, each segment of the technology development pipeline requires specialized expertise in understanding that environment. For example, understanding the barriers to moving successful applied research on solar panels into the prototype phase is likely very different than understanding the market barriers to consumers adopting electric vehicles. In our investigation, we could not identify any single state entity with the diverse expertise necessary to analyze all of the state investments in clean energy and transportation technology. For that reason, the Legislature may want to consider forming an advisory panel composed of experts in each area and segment of the pipeline to provide analysis and recommendations to state policy makers on investments to support technology innovation.

To ensure recommendations from the panel are free from special interest bias, non-conflicted experts should be carefully recruited using a selection process like the one utilized by the National Academies of Sciences, Engineering, and Medicine, which is widely considered to be among the most robust and transparent in preventing conflicts of interest and adequately selecting for appropriate expertise.[22]

There are potentially many issues for such an advisory board to address, but based on our assessment, we suggest the advisory panel provide recommendations to address, at a minimum, the following:

Removing redundancies and promoting coordination. An expert advisory panel could be tasked with identifying program duplication between existing state, federal, and local financial incentive programs. The advisory panel could analyze program constraints and identify opportunities to streamline, restructure, or eliminate redundant programs. The panel also could identify programs that support similar technology development more comprehensively along the pipeline. We found many programs to be narrowly focused on their particular jurisdiction, and an expert panel could look for opportunities to encourage cross-agency coordination and technology innovation along the entire pipeline.

Additionally, the panel could address any other concerns related to having a large number of programs focused on similar goals. For example, the panel could identify areas where programs are being underutilized due to a lack of information or confusion among interested consumers. The panel could identify whether increasing outreach efforts, such as creating a clearinghouse, would improve program effectiveness.

Achieving a balanced investment portfolio. Balancing investments between pulling and pushing strategies is important for cost effectiveness and preventing deployment of inefficient technologies. Our analysis suggests that California state investments are likely to be heavily weighted toward pulling strategies. An expert panel could consider how best to balance investments between technology areas reflecting the best strategies to reach the state's policy goals. Achieving a balanced investment portfolio is complicated as the research literature shows that debate on optimal investment levels is not conclusive and is very sector-specific. The panel could consider technologies on the horizon that have breakthrough potential, as well as scaling timelines including economic costs. In addition to reviewing state programs, the panel also could perform a gap analysis of existing federal and local programs.

Addressing market failures and leveraging private capital. Public investments for clean technology development should be strategically targeted to address market failures. However, a recent review by the Legislative Analyst's Office found limited evidence that the current mix of transportation policies addressing climate change targets market failures.[23] As was previously discussed in the pipeline section, clean technology is at a disadvantage in

attracting private capital because other investment opportunities offer greater and more reliable returns on much shorter timelines. This challenge is particularly significant in the earlier stages of technology development. The panel could study where the market failures in technology development are most critical and develop strategies for target intervention in those areas.

While it is difficult to quantify the additional funding needed to meet the state's goals, several assessments of the required investments in specific areas help illustrate the magnitude of the investment needs and the importance of the private sector's contribution. For example, a study commissioned by the California Public Utilities Commission (CPUC) concluded it would take approximately $4 billion annually in new investment to meet state targets for energy-efficiency retrofits.[24] Further, the South Coast Air Quality Management District has estimated it needs about $1 billion annually to help deploy the zero-emission vehicles and infrastructure necessary to reach its air quality goals, while less than $150 million annually is being provided.[25] It is important to note that the studies assessed the cost of deploying existing technology into the market without accounting for the development of new technology that could drive down deployment costs.

The panel could consider how to target state investments in key areas to leverage private capital, such as through the strategic use of credit enhancements. One of the primary advantages of credit enhancements is that they allow the state to utilize a relatively small amount of public funding to leverage a large amount of private capital. For example, according to CAEATFA, its PACE loan loss reserve program, which was funded through a one-time general fund appropriation of $10 million in 2013, has more than $3.4 billion in PACE financings enrolled in the program. To date, it has yet to pay a single claim out against the reserve.[26]

A number of states have explored financing clean energy projects through the development of a state green bank.[27] While the exact form of a green bank can vary, its main purpose is to use public funding to leverage private capital for clean energy and energy efficiency projects. Other qualities of green banks include the consolidation of funding sources into a single green financing fund, the ability to issue bonds, and the authorization to utilize financing mechanisms such as direct loans, co-lending, and credit enhancements to support green technology. Successful examples of the establishment of green banks include the Clean Energy Finance and Investment Authority in Connecticut and the New York State Energy Research and Development Authority. While California has a number of programs and financing authorities that fulfill functions similar to a central green bank, the expert panel could consider how aspects of existing green bank models could be applied to the state.

APPENDIX: STATE PROGRAMS PROVIDING FINANCIAL INCENTIVES FOR CLEAN ENERGY AND TRANSPORTATION TECHNOLOGY DEVELOPMENT

The tables on pages 14-17 show the 40 state programs examined in this report. Table 1A shows a description of each program. Table 2A shows the following information for each program:

- FY 2018–19 funding level
- Cumulative funding received through FY 2018–19
- Location on technology development pipeline
- Name of program administrator (to whom a consumer would apply for funding)
- Name of the lead agency (who controls the funds)
- Technology category (renewable energy, energy efficiency, or clean transportation)
- Type of financial incentive

We included programs that meet the following criteria:

- Financial incentive programs that primarily target clean energy or transportation technologies
- Currently providing funding in FY 2018–19
- A state program, authorized by the Legislature, which provides public funds under the oversight of a state agency

Examples of programs that did not meet our criteria for inclusion are:

- Bioenergy Market Adjusting Tariff and Renewable Market Adjusting Tariff feed-in tariff programs. Although the programs provide financial incentives through a feed-in tariff, the CPUC views them not to be a financial incentive program, but rather a procurement mandate.

- Climate Change Research Program administered by the Strategic Growth Council. Although one grant was awarded to an energy efficiency technology project in the 2018 solicitation, the program does not specifically target clean energy or transportation technologies.

- Volkswagon (VW) Environmental Mitigation Trust administered by ARB. This program plans on funding mostly commercial deployment projects for heavy-duty vehicles and equipment, but was created from a settlement with VW and was not explicitly authorized by the Legislature.

Funding levels shown in the table include administrative costs and represent budget authority, not actual expenditures. Programs that did not have funding levels available are represented by N/A in the table. For example, the Net Energy Metering (NEM) program administered by IOUs does not have funding or expenditure reporting requirements. We decided to include programs such as these to provide a complete picture of all state

programs that provide financial incentives for clean energy and transportation technology. In some cases, such as for NEM, program costs have been analyzed by external entities and could be included in an analysis of state investments by a potential expert panel.

Please note, the cumulative funding levels through FY 2018–19 found in the table for CAEATFA's Sales and Use Tax Exclusion (STE) Program include $338 million in STE usage.

Acronym List

ARB	California Air Resources Board
AR	Applied Research
BAAQMD	Bay Area Air Quality Management District
BOE	Board of Equalization
BSF	Beneficial State Foundation
CAEATFA	California Alternative Energy and Advanced Transportation Financing Authority
CDFA	California Department of Food and Agriculture
CEC	California Energy Commission
CD	Commercial Deployment
CPCFA	California Pollution Control Financing Authority
CPUC	California Public Utilities Commission
CSD	Department of Community Services and Development
CSE	Center for Sustainable Energy
CT	Clean Transportation
CVA	California Vanpool Authority
Demo	Demonstration
EE	Energy Efficiency
LAD	Local Air Districts
IOUs	Investor Owned Utilities
NCAQMD	North Coast Air Quality Management District
Proto	Prototype
RE	Renewable Energy
SJAPCD	San Joaquin Air Pollution Control District
SCAQMD	South Coast Air Quality Management District
SCAQMD	Sacramento Metro Air Quality Management District

Table 1A

PROGRAM NAME	DESCRIPTION
Electric Program Investment Charge-CEC	Funds energy-efficiency and renewable energy research, development, and demonstration projects
Natural Gas R&D Program	Funds research, development, and demonstration project to support cost-effective energy-efficiency and conservation activities
Food Production Investment Program	Funding to food processors for development and demonstration projects that reduce greenhouse gas emissions
Electric Program Investment Charge-IOU	Funds renewable energy technology demonstration and deployment projects
Advanced Technology Freight Demonstrations and Freight Facilities	Funding for freight demonstration projects (including facilities, drayage trucks, off-road equipment, and advanced engines) to help bring new zero-emitting technologies to market
Zero-Emission Warehouse Project	Funding program that advances implementation of zero-and near zero-emission warehouses and technologies
Property Tax Exclusion for Solar Energy Systems	Exclusion from property tax assessment for newly constructed solar energy systems
Renewable Energy for Agriculture Program	Funding to assist agriculture operations with the installation of on-site renewable energy technologies
Demand Response	Pricing incentives for residential, commercial, agricultural, and industrial customers to reduce or shift their electricity usage to certain times in the day when renewable resources like the wind or sun are available
Net Energy Metering	Provides a financial credit on electric bills for customers who install small solar, wind, biogas, and fuel cell generation facilities and supplies any surplus energy back to their utility
California Solar Initiative-Thermal Program	Financial incentives for residential and commercial solar water heating and other solar thermal technologies
Self-Generation Incentive Program	Financial incentives on the customer's side of the utility meter to support distributed energy resources
Dairy Digester Research and Development Program	Financial assistance for the installation of dairy digesters
Sales and Use Tax Exclusion (STE) Program	Provides a sales and use tax exclusion to manufacturers of alternative energy products and advanced transportation technologies, advanced manufacturers, and recyclers.
Property Assessed Clean Energy (PACE) Loss Reserve Program	Increases availability of residential PACE financing by making first mortgage lenders whole for direct losses as a result of a PACE lien in a foreclosure or forced sale.
Low-Income Weatherization and Solar	Funding for solar photovoltaics, solar water heaters, and energy-efficiency measures in low-income single family and multi family dwellings
California Hub for Energy Efficiency Financing (CHEEF) Pilot Programs	Leverages private lending and investment for energy-efficiency technologies with various credit enhancements and OBF
IOU Energy Efficiency Programs	Financial incentives to develop programs to transform energy-efficiency technology markets for residential homes and commercial buildings, large and small appliances, lighting and HVAC, industrial and agriculture
IOU On-Bill Financing Programs	0% loans for energy efficiency technologies for IOU customers
State Water Efficiency and Enhancement Program	Provides financial assistance to implement irrigation systems that reduce greenhouse gases on California agricultural operations

PROGRAM NAME	DESCRIPTION
Woodsmoke Reduction Program	Incentives for households to replace uncertified wood stoves, wood inserts, or fireplaces with cleaner burning and more energy-efficient home heating devices
California Lending for Energy and Environmental Needs (CLEEN) Center	Direct financing to municipalities, universities, schools, and hospitals for energy-efficiency upgrades and the installation of LED streetlights
Electric Vehicle Charging Station Financing Program	Incentives to install electric vehicle charging stations for small business owners and landlords
Alternative and Renewable Fuel and Vehicle Technology Program	Promotes accelerated deployment of advanced transportation and fuel technologies
IOU Transportation Electrification Program	Financial incentives for charging stations for both light-duty passenger EVs and medium/heavy-duty Evs
Clean Vehicle Rebate Project	Rebates for light-duty ZEVs, plug-in hybrid electric vehicles, and zero-emission motorcycles.(includes Public Fleets Pilot)
Enhanced Fleet Modernization Program (EFMP)/Clean Cars 4 All	Incentives for disadvantaged communities to purchase a new or used hybrid, plug-in hybrid, or ZEV
Clean Mobility Options for Disadvantaged Communities	Funding for various clean mobility options that increase access to zero-emission and plug-in hybrid car sharing and other clean mobility options
Financing Assistance for Lower-Income Consumers	Provides low-interest loans and vehicle price buy-downs to consumers for the purchase of plug-in hybrid and battery electric vehicles. Also includes a loan loss reserve to encourage lender participation
Agricultural Worker Vanpools	Provides incentives to expand access to clean transportation vanpools retrofitted with add-on hybrid technology for agricultural workers
Zero-Emission Off-Road Freight Vouchers	Funding for fleets ready to purchase specific zero-emission equipment
Rural School Bus Pilot Project	Funding for zero emission, hybrid buses, and new conventionally fueled school buses that use renewable fuels
The Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) and Low NOx Engine Incentives	Funding to support the long-term transition to zero-emission vehicles in the heavy-duty market, as well as supporting near-term technology to help meet air quality standards
Clean Mobility in Schools	Funding for K–12 schools located in a disadvantaged community to support clean mobility options such as the electrification of the school's yellow and white fleet, ZEV car sharing, and outreach
Truck Loan Assistance Program	A loan loss reserve program to help small-business fleet owners secure financing for upgrading their fleets with newer trucks or with diesel exhaust retrofits
Diesel Emission Retrofit Replacement Filters	Supports filter substrate replacements for existing heavy-duty vehicles
Funding Agricultural Replacement Measures for Emission Reductions (FARMER) Program	Incentives to reduce agricultural sector emissions from harvesting equipment, heavy-duty trucks, agricultural pump engines, tractors, and other equipment used in agricultural operations
Carl Moyer Memorial Air Quality Standards Attainment Program	Funding for clean engines and equipment including trucks, school and transit buses, off-road equipment, marine vessels, locomotives, agricultural equipment, light-duty vehicle scrap, and lawn mowers
Community Air Protection Program	Funding to target engine replacement, repower, and clean transportation infrastructure projects in disadvantaged and low-income areas

Table 2A

PROGRAM NAME	FY 18–19 FUNDING ($MILLION)	CUMULATIVE FUNDING THROUGH FY 2018–19 ($MILLION)	PIPELINE LOCATION	ADMINISTRATOR	LEAD AGENCY	TECHNOLOGY CATEGORY	INCENTIVE CATEGORY
Electric Program Investment Charge-CEC	148	1,019	AR/Proto/ Demo/CD	CEC	CPUC	RE/EE	Grant
Natural Gas R&D Program	24	306	AR/Proto/ Demo/CD	CEC	CPUC	RE/EE/CT	Grant
Food Production Investment Program	64	124	AR/Proto/ Demo	CEC	CEC	RE/EE	Grant/Loan
Electric Program Investment Charge-IOU	37	255	Demo/CD	IOUs	CPUC	RE/EE	Grant
Advanced Technology Freight Demonstrations and Freight Facilities	55	236	Demo/CD	ARB	ARB	CT	Grant
Zero-Emission Warehouse Project	0	50	Demo/CD	ARB	ARB	CT	Grant
Property Tax Exclusion for Solar Energy Systems	N/A	N/A	CD	BOE	BOE	RE	Tax Incentive
Renewable Energy for Agriculture Program	4	10	CD	CEC	CEC	RE	Grant
Demand Response	251	1,830	CD	IOUs	CPUC	RE	On-bill Program
Net Energy Metering	N/A	N/A	CD	IOUs	CPUC	RE	Rebate
California Solar Initiative-Thermal Program	N/A	168	CD	IOUs	CPUC	RE	Rebate
Self-Generation Incentive Program	N/A	1,347	CD	IOUs	CPUC	RE	Rebate
Dairy Digester Research and Development Program	71	204	CD	CDFA	CDFA	RE	Grant
Sales and Use Tax Exclusion (STE) Program	2	351	CD	CAEATFA	CAEATFA	RE/CT	Tax Incentive
Property Assessed Clean Energy (PACE) Loss Reserve Program	1	11	CD	CAEATFA	CAEATFA	RE/EE	Loan
Low-Income Weatherization and Solar	10	202	CD	CSD	CSD	RE/EE	Grant
California Hub for Energy Efficiency Financing (CHEEF) Pilot Programs	4	17	CD	CAEATFA	CPUC	EE	Loan/OBF
IOU Energy Efficiency Programs	822	12,723	CD	IOUs	CPUC	EE	Rebate/OBF/loan/direct payments
IOU On-Bill Financing Programs	64	277	CD	IOUs	CPUC	EE	OBF
State Water Efficiency and Enhancement Program	20	88	CD	CDFA	CDFA	EE	Grant

PROGRAM NAME	FY 18–19 FUNDING ($MILLION)	CUMULATIVE FUNDING THROUGH FY 2018–19 ($MILLION)	PIPELINE LOCATION	ADMINISTRATOR	LEAD AGENCY	TECHNOLOGY CATEGORY	INCENTIVE CATEGORY
Woodsmoke Reduction Program	3	8	CD	LADs	ARB	EE	Rebate
California Lending for Energy and Environmental Needs (CLEEN) Center	N/A	N/A	CD	Ibank	Ibank	EE	Loan
Electric Vehicle Charging Station Financing Program	0	2	CD	CPCFA	CEC	CT	Loan
Alternative and Renewable Fuel and Vehicle Technology Program	165	1,109	CD	CEC	CEC	CT	Grant/Loan
IOU Transportation Electrification Program	23	1,006	CD	IOUs	CPUC	CT	Grant/Rebate
Clean Vehicle Rebate Project	200	856	CD	CSE	ARB	CT	Rebate
Enhanced Fleet Modernization Program (EFMP)/ Clean Cars 4 All	16	112	CD	SCAQMD, SJAPCD, BAAQMD, SMAQMD	ARB	CT	Grant
Clean Mobility Options for Disadvantaged Communities	15	47	CD	ARB	ARB	CT	Grant
Financing Assistance for Lower-Income Consumers	10	36	CD	BSF	ARB	CT	Loan/Rebate
Agricultural Worker Vanpools	3	9	CD	CVA	ARB	CT	Grant
Zero-Emission Off-Road Freight Vouchers	0	40	CD	ARB	ARB	CT	Voucher
Rural School Bus Pilot Project	15	55	CD	NCAQMD	ARB	CT	Grant
The Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP) and Low NOx Engine Incentives	125	442	CD	CALSTART	ARB	CT	Voucher
Clean Mobility in Schools	10	10	CD	ARB	ARB	CT	Grant
Truck Loan Assistance Program	26	152	CD	CPCFA	ARB	CT	Loan
Diesel Emission Retrofit Replacement Filters	3	3	CD	ARB	ARB	CT	Grant
Funding Agricultural Replacement Measures for Emission Reductions (FARMER) Program	132	267	CD	LADs	ARB	CT	Grant
Carl Moyer Memorial Air Quality Standards Attainment Program	79	1,159	CD	LADs	ARB	CT	Grant
Community Air Protection Program	245	495	CD	LADs	ARB	CT	Grant
Lower Emission School Bus Program	1	321	CD	SJAPCD	ARB	CT	Grant

Endnotes

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10 For further discussion of California IP stewardship issues see Appendix A of https://sor.senate.ca.gov/sites/sor.senate.ca.gov/files/0842%20policy%20matters%20Research%2003.18%20Final.pdf.

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