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Economic Impacts Associated with Commercializing Fuel Cell Electric Vehicles in California: An Analysis of the California Road Map Using the JOBS H2 Model

Energy Systems Division

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Economic Impacts Associated with Commercializing Fuel Cell Electric Vehicles in California: An Analysis of the California Road Map Using the JOBS H2 Model

by
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December 31, 2014

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ACKNOWLEDGMENTS

This work has benefited from the advice and assistance of many individuals and organizations. Fred Joseck and Sunita Satyapal of the U.S. Department of Energy's Fuel Cell Technologies Office provided overall direction and support, as well as valuable input and suggestions. Nico Bouwkamp of the California Fuel Cell Partnership provided insightful review of this document, as did Gerhard Achtelik and Andrew Martinez of the California Air Resources Board. We thank them all for their time and expertise, which materially improved the content, accuracy, and quality of this work.

ACRONYMS

BEV	Battery electric vehicle
CaFCP	California Fuel Cell Partnership
CEC	California Energy Commission
DOE	U.S. Department of Energy
FCEV	Fuel cell electric vehicle
FCTO	Fuel Cell Technologies Office (DOE)
HyPPO	Hydrogen Progress, Priorities, and Opportunities (CaFCP report)
O&M	Operation and maintenance
OEM	Original equipment manufacturer
PHEV	Plug-in hybrid electric vehicle
ZEV	Zero emissions vehicle

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EXECUTIVE SUMMARY

Successful implementation of the California Road Map (the Road Map) for the introduction of hydrogen fueling stations (CaFCP 2014) to support a fleet of fuel cell electric vehicles (FCEVs) will produce positive economic impacts. Those impacts include jobs created or retained to develop and operate hydrogen fueling stations, earnings by businesses and workers so employed, and economic output generated by the activities required to develop and operate the stations. This report summarizes an analysis of those impacts as conducted by Argonne National Laboratory and RCF Economic and Financial Consultants for the U.S. Department of Energy's Fuel Cell Technologies Office (FCTO). The analysis assumes that the cost and technical performance of stations that received awards under the 2014 solicitation of the California Energy Commission (CEC Solicitation PON-13-607 Notice of Proposed Awards of May 1, 2014) are representative of all stations to be deployed under the Road Map (subject to scale effects)[1] and that information supplied by applicants representing the majority of those stations is representative of all. The analysis further assumes that all stations will be of a design similar to those developed in the initial years of the rollout, with additional equipment added as modules to achieve the targeted station capacity specified in the Road Map.

Because of variations in the capacity of stations, when they are (or were) placed in-service or commissioned, and thus how long they will accrue impacts over the timeframe of the Road Map (i.e., 2015–2022), the analysis was conducted in two parts. The first focused on the group of 28 ("2015 rollout") stations expected to be designed and built in 2015. The second considered stations to be built in the 2016–2022 timeframe ("post-2015 rollout"), as well as the continued operation of another group of stations that are either currently operational or expected to become operational in 2015. (Findings are discussed in Section 5, Reference Scenario Results.)

Economic impacts reported herein include only those expenditures likely to occur in California. It was assumed that hydrogen storage systems (i.e., cascade systems and perhaps buffer storage) are the only equipment likely to be manufactured in California. It was also assumed that station design and construction activities would take place in-state, as would all expenditures associated with hydrogen production and delivery and station operation. A bounding analysis in which all expenditures were assumed to be in-state was also conducted (the "All Within California" Case discussed in Section 6).

ES.1 2015 ROLLOUT ANALYSIS

The 28 newly funded stations are estimated to produce 330 jobs for planning/design, site development, equipment production, installation, etc. (i.e., station development) and an additional 150 jobs for station operation. Earnings are estimated to be $18 million and

[1] Stations to be deployed in the latter years of the Road Map will have greater daily capacity than those deployed in the initial years. Because initial cost varies non-linearly with capacity, these latter stations will be more costly although cost per unit of capacity will decline.

$8 million, respectively, for station development and operations, while economic output is estimated to be $57 million and $29 million, respectively. All benefits from station development are assumed to accrue during a one-year period, whereas those from operations begin to accrue in the first year of operation and continue as long as the station operates.

ES.2 POST-2015 OR LONG-TERM ROLLOUT ANALYSIS

Results for the long-term rollout include impacts from operating the 23 stations reportedly in existence in 2015 and the 28 stations added in 2015, as well as from developing and operating a variable number of stations each year from 2016 through 2022. Impacts are calculated by year from 2015 through 2023.

ES.2.1 Employment

Because the rollout assumes deployment of fewer stations each year after 2015, employment in the long-term analysis drops significantly (from 330 to 90 jobs) in 2016 as the number of new stations declines from 28 to 8. Development jobs increase to 240 in 2022 as the number and capacity of new stations increase over this timeframe. Approximately 65% of station development jobs are attributable to supply chain impacts.

Jobs associated with station operation are shown in Figure ES-1. Results are broken down by both the year in which employment occurs and station vintage (i.e., stations in operation in 2015, and stations added by year in the 2016–2022 time frame).

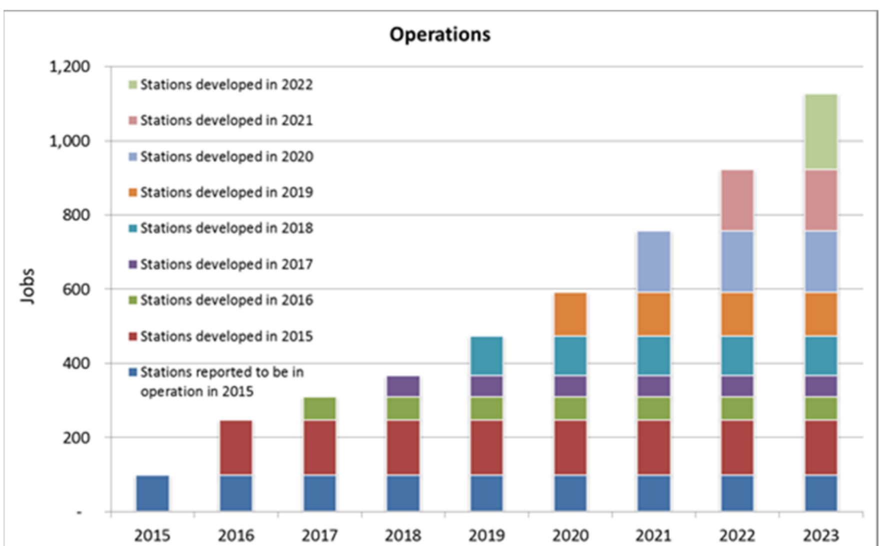

FIGURE ES-1 Employment in California from Operating H2 Fueling Stations by Year and Station Development Time Frame

ES.2.2 Earnings and Economic Output

Total earnings and total economic output are shown in Figures ES-2 and ES-3, respectively. Near-term (e.g., one-year) earnings and economic output resulting from the development of new stations exceed the annual earnings and economic output that will result from operating these same stations in subsequent years.

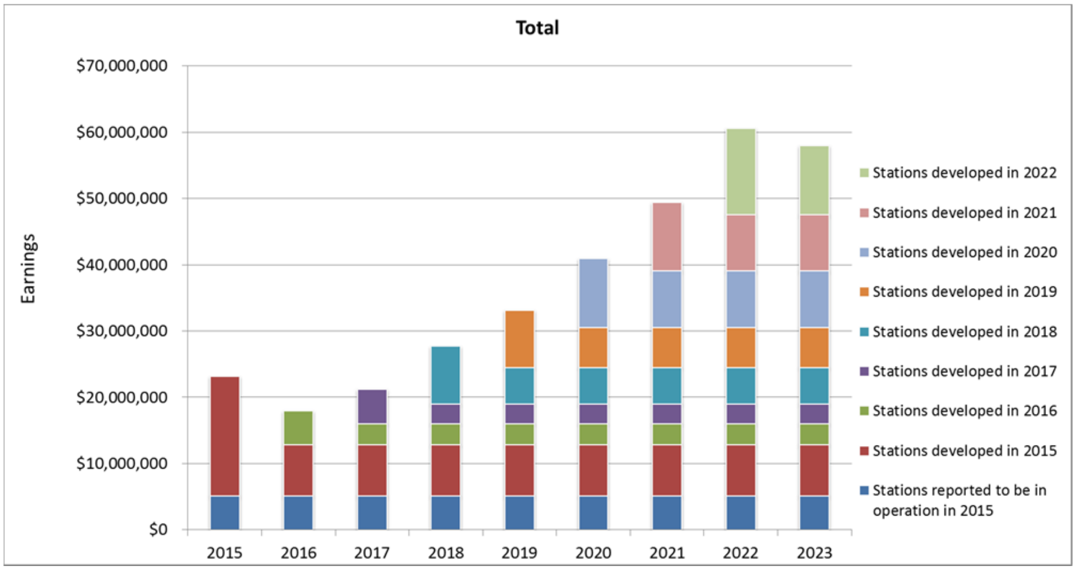

FIGURE ES-2 Earnings from Developing and Operating Hydrogen Fueling Stations by Year and Station Development Time Frame

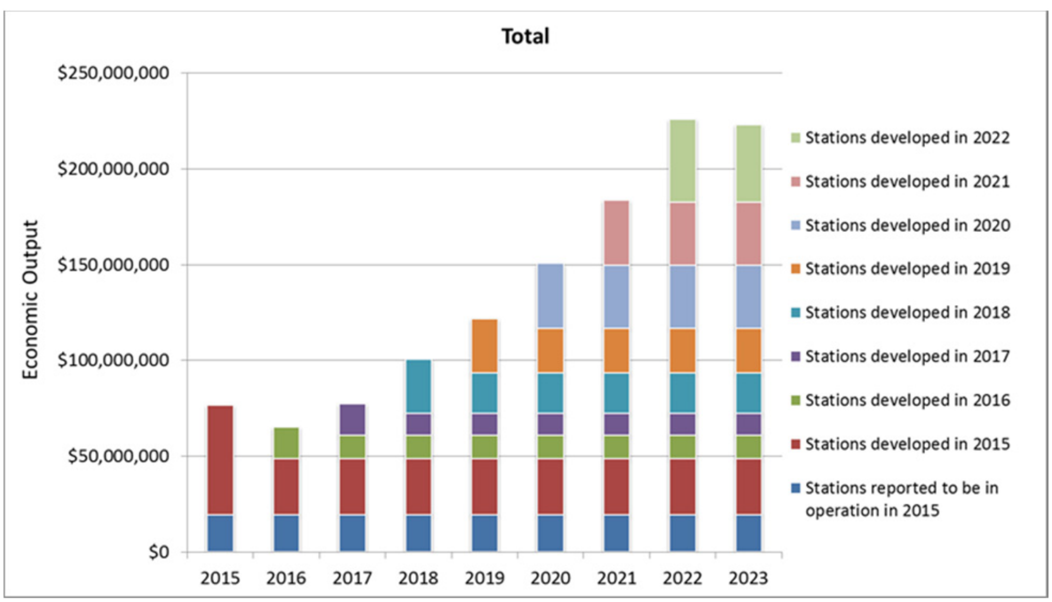

FIGURE ES-3 Economic Output from Developing and Operating Hydrogen Fueling Stations by Year and Station Development Time Frame

ES.3 "ALL WITHIN-CALIFORNIA" CASE

As a way of bounding the estimates of economic benefits, an analysis was conducted in which it was assumed that all expenditures associated with station development and operation occur in California and thus, all benefits accrue within the state.

ES.3.1 Employment

Results suggest that in-state employment attributable to the Roadmap could increase by 100% or more if all expenditures were to occur within California. While this case is perhaps unlikely, it does indicate the significance of local manufacturing in benefit estimation. No additional employment gains occur from station operation because the Reference Scenario already assumed that hydrogen would be produced in California and that all expenses associated with station operation and maintenance would occur in California.

ES.3.2 Total Earnings and Total Economic Output

Earnings increase by approximately \$4 million in 2016 and \$20 million in 2022 as compared with the Reference Scenario while total economic output rises by approximately \$20 million in 2016 and \$70 million in 2022. Although earnings and economic output are higher if all expenses associated with station development occur in California, the percentage increase over the Reference Scenario is less dramatic than for employment estimates.

ES.4 MODIFIED ROLLOUT SCENARIO

Based on progress to date, fewer stations may be operational in 2015 than are indicated in the Road Map. Furthermore, the design and construction period for hydrogen fueling stations may be longer than the one year, as suggested in the *Hydrogen Progress, Priorities, and Opportunities* (HyPPO) document. To examine the effect of these changes on results, a modified rollout scenario (the Alternate Scenario) was developed. Results of that analysis are presented in Appendix A. Although total employment and other economic impacts do not change under this scenario, year-by-year impacts are delayed as compared with the Reference Scenario.

1 BACKGROUND AND OVERVIEW

Following years of research, development, and demonstration and the commitment of various governments to the elimination of tailpipe emissions, a number of original equipment manufacturers (OEMs) have begun selling or leasing zero emission vehicles (ZEVs). The U.S. government and several states are assisting those efforts through a variety of rebates, tax credits, and other incentives to reduce the cost of ZEVs and increase the availability of supporting infrastructure. In addition, California, Connecticut, Maryland, Massachusetts, New York, Oregon, Rhode Island, and Vermont have committed to developing a coordinated program to advance the commercialization of battery electric vehicles (BEVs), plug-in hybrid electric vehicles (PHEVs), and fuel cell electric vehicles (FCEVs). By signing a Memorandum of Understanding, the governors of those states created a multi-state ZEV Program Implementation Task Force to guide these efforts. In May 2014, the Task Force issued a *Multi-State ZEV Action Plan* containing key actions that the signatory states will undertake to promote the development of the ZEV market (ZEVTF 2014).

Unlike conventional vehicles, ZEVs cannot be refueled at the thousands of existing gasoline stations. The lack of fueling infrastructure is often cited as a major barrier to consumers looking to purchase ZEVs, as well as to ZEV owners looking to drive their vehicles any appreciable distance. OEMs are trying to mitigate this problem by including fuel in their lease agreements and/or working with industrial gas companies to develop fueling infrastructure.

California has gone even further, adopting legislation to support the development of a network of strategically located fueling stations for a growing fleet of FCEVs in that state. In July 2014, the California Fuel Cell Partnership (CaFCP) issued an update to its 2012 report, *A California Road Map: The Commercialization of Hydrogen Fuel Cell Electric Vehicles* (CaFCP 2012). Titled *Hydrogen Progress, Priorities, and Opportunities* (HyPPO), the update resumes where the earlier document left off, summarizing progress achieved from 2012–2014 and planned for 2014–2016, and proposing a Road Map to guide FCEV and related infrastructure rollout for the years beyond (CaFCP 2014). According to the latter document, 23 hydrogen fueling stations are expected to be in operation within the state in 2015, and an additional 28 stations will be brought online by the end of 2015. These “2015 rollout” stations are supported by a $49 million award from the California Energy Commission (CEC). (Note that although there has been no official acknowledgement, there are indications that there has been some slippage in station deployment from the schedule laid out in the HyPPO (CaFCP 2014) document. See Appendix A for an analysis of the impact of unofficial near-term delays in deploying hydrogen fueling stations in California.)

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2 INTRODUCTION

The U.S. Department of Energy (DOE), California and the other states involved in the multi-state task force, and various stakeholders are keenly interested in understanding the potential impact of investments in FCEVs and supporting infrastructure. Estimates of jobs created or supported and other economic impacts from the introduction of FCEVs are important as officials weigh policies and consider adopting incentives to promote market uptake. Such estimates are also important to DOE — both to justify research and development efforts related to FCEVs and related infrastructure, and to compare the results of those investments to other options.

The analyses documented here are based on the material contained in CaFCP's HyPPO report. The analyses were requested by the DOE's Fuel Cell Technologies Office (FCTO) using the JOBS H2 (JOBS and economic impacts of Hydrogen) model developed with the support of that office.

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3 METHODOLOGY

The basic tool used in this analysis is the JOBS H2 model. Developed by Argonne National Laboratory and RCF Economic and Financial Consulting, Inc., for the DOE's FCTO, Version 1.01 of the model is available at http://jobsmodels.es.anl.gov. As noted in documentation posted at that site, JOBS H2 1.01 is a spreadsheet tool designed to help users estimate economic impacts from the development and operation of hydrogen fueling stations in the United States. It must be emphasized that JOBS H2 is a tool for estimating economic impacts for a user-defined case of hydrogen fueling station development and operation and is not a forecast model for station utilization (Mintz et al., 2013).

JOBS H2 1.01 uses input-output methodology to estimate economic impacts associated with expenditures involved in the development and operation of hydrogen fueling stations, and calculates the ripple effects of those expenditures through the economy. It captures the economic impact of major activities (via supply chains and induced effects), including the manufacture and deployment of hydrogen fueling equipment, pre-construction and construction of hydrogen fueling stations, and the operation of those stations (including the production and sale of hydrogen and other station operating and maintenance [O&M] expenses). The tool can be run with default values or user input for many of the station cost and performance parameters. The tool uses input-output methodology to convert total dollars spent into economic impacts using relationships from the Regional Input-Output Modeling System developed by the U.S. Department of Commerce's Bureau of Economic Analysis (Bess and Ambargis 2011).

The tool has been designed to be as flexible as possible and to allow users with diverse interests to estimate economic impacts. JOBS H2 1.01 is Microsoft Excel-based with spreadsheet tabs for inputs and results. It is assumed that the user has a basic knowledge of Excel 2010 and general familiarity with hydrogen fueling stations. Excel 2010® (or later versions) is required in order to make full use of the functionality of the tool.

Because of differences in scope, this analysis was conducted in two parts. The first focused on the early commercialization phase as contained in the HyPPO report discussed previously. That report calls for 28 new fueling stations to begin operation on October 31, 2015, per the CEC's funding requirements. The number of stations and the anticipated timing of their rollout are consistent with the recent CEC award mentioned in Section 1. This information provided the basis for the JOBS H2 input. However, because the model works on a calendar year basis, it was assumed that the design and construction of these stations would occur during calendar year 2015 and full-scale operation would not begin until January 1, 2016.

The second part of the analysis examined the long-term rollout of fueling stations. Design and construction of stations expected to become operational during the 2016–2022 time frame were considered, as was the continued operation of all stations. As reported in the 2014 HyPPO, 23 stations were expected to be fully operational in 2015. These stations were assumed to continue to operate at their nominal capacity through at least 2023 (i.e., no shutdowns or capacity expansions were expected to occur for these stations). However, for this analysis, only expenses associated with *operating* these 23 stations are considered given that expenses associated with their design and construction are “sunk costs” whose benefits have already accrued. For stations going online in 2016 and beyond, however, the analysis includes *all* expenses associated with design, construction, and operation, and it estimates jobs and other economic benefits associated with those expenses.

By conducting the analysis in this two-part manner, the results for the near-term rollout (i.e., the 28 new stations scheduled to become operational in late 2015 [assumed to be January 1, 2016, in the model]) could be examined more closely while also gaining a longer-term picture for the extended rollout through 2022.

4 ASSUMPTIONS

In conducting the analysis, several assumptions were made with respect to the information input to JOBS H2. Some of these were necessary because of the structure of the current version of the model; others were needed because of the limited information readily available to the analysts. The major assumptions regarding model input are summarized below.

4.1 2015 ROLLOUT ANALYSIS

As noted above, 28 proposed hydrogen fueling stations received awards from the CEC to be brought online by the end of 2015. These stations included delivery of gaseous and liquid hydrogen, on-site generation of hydrogen via electrolyzers or steam methane reformer systems, and mobile fueling stations. Version 1.01 of JOBS H2 considers only delivery and storage of hydrogen in gaseous form and does not consider any type of on-site hydrogen production. The analysis therefore assumed that all 28 stations receive, store, and dispense hydrogen in gaseous form. In addition, 19 of the awards are for stations of identical design. Therefore, for purposes of this analysis, it was assumed that all 28 stations had cost and performance characteristics corresponding to the 19 identical stations. These assumptions permitted the analysis to be conducted within the framework of JOBS H2 Version 1.01 while using cost and performance information representative of the vast majority of awardees. Although no formal uncertainty analysis has been conducted, the authors believe the results obtained under these assumptions are representative of those that would be obtained in a more exacting analysis and are well within any reasonably expected range of uncertainty.

It should be noted that by assuming that all of the 28 stations have a design capacity of 180 kg/day, the total capacity added during the year is 5,040 kg/day, whereas the rollout calls for 5,960 kg/day of new capacity. Thus, the results of the JOBS H2 analysis can be expected to *slightly underestimate* the number of jobs and other economic benefits of the 2015 rollout.

4.1.1 Equipment Costs

Some cost information provided for the Reference Scenario's 2015 rollout stations did not correspond to the cost structure built into JOBS H2. Therefore, it was necessary to allocate reported costs among the dispenser, refrigeration system, and compressor from more aggregate data reported for the representative station as proposed to the CEC. Specific costs were provided for the cascade storage, electrical equipment, and overall control and safety equipment. It should be noted that some components of the proposed stations were intentionally designed in excess of the nominal station capability of 180 kg/day.

4.1.2 Station Development and Other Costs

Installation costs, engineering and design costs, and permitting costs were input to the model as presented in the proposal. Because no contingency costs were identified in the proposal, this cost was input to the model as $0. Again, total costs were set equal to those reported in the proposal.

4.1.3 Operation and Maintenance Costs

Operating costs were also provided in the proposal. Assuming a lifetime 80% utilization factor (assumed to be constant), hydrogen production cost was taken as $5.00/kg, delivery cost as $0.50/kg, and station O&M cost as $2.00/kg. The JOBS H2 cost referred to as "retail" was then determined to be $2.30/kg from the total cost of $9.80/kg as provided in the proposal. The authors recognize that utilization of these stations in the first years of operation is likely to be less than 80%; however, this value is used in the analysis in order to be consistent with the 2014 HyPPO report.

4.1.4 Analysis Region and In-Region Shares

JOBS H2 estimates jobs and economic impacts within a specified geographic region. Benefits that might accrue outside the region of interest are not considered. In this case, the region of interest is the state of California. It is therefore important to estimate what portion of station expenses will occur inside California. In the proposal, the awardee specifically notes that the cascade storage system will be provided by a California company. As the hydrogen fueling stations will be located within the state, all construction and installation expenses were assumed to occur in state, as well; furthermore, the hydrogen was assumed to be produced in California, and all O&M expenses were assumed to be incurred in state. It was also assumed that all design, permitting, and similar functions would be in-state activities. The awardee noted that approximately $1 million will be spent in California for each station. The equipment cost for the cascade storage system, the various engineering and installation expenses, and one year of operating costs total slightly more than $1 million. Therefore, these costs were assumed to reflect the intent of the awardee and were modeled as in-state expenditures.

4.2 LONG-TERM ROLLOUT ANALYSIS

The CaFCP's updated rollout (the HyPPO document, CaFCP 2014) provides information on fueling stations that are currently in operation or under construction and those that are planned to be added each year through 2022. The second part of our analysis estimated jobs and economic benefits for this longer-term rollout. While information on the 2015 rollout is available as discussed above, the HyPPO provides little design information on stations expected after that time because no proposals for these stations are available. Therefore, several additional assumptions were needed to conduct the long-term analysis.

4.2.1 Design Capacity and Number of New Stations

The HyPPO document provides information on the number of stations and total capacity added for each year. It was assumed that all stations added in a given year would have the same design capacity.

4.2.2 Design Capacity, Number, and Utilization of Existing Stations

The HyPPO document reports that 23 stations with a total capacity of 3,300 kg/day (an average of approximately 143 kg/day) will be operational in California in 2015. The rollout assumes that these stations continue operating with an 80% annual utilization factor over the period of interest. Capital expenses for these stations are assumed to have already been incurred; thus, only the jobs and economic benefits associated with their operation were considered. It was assumed that hydrogen production and delivery and "retail" costs for these stations are the same as for the stations in the 2015 Rollout. The costs associated with the operation and maintenance of the stations were adjusted slightly to account for differences in the nominal capacity of the stations.

4.2.3 Other Costs of New Stations

As no information is available on the cost or design details of future stations beyond the 2015 rollout, it was assumed that their basic design and cost parameters would be based on the 2015 rollout case described above. The Reference Scenario's design for the 2015 rollout noted that some equipment was over-designed for the nominal 180 kg/day. The proposal also noted what other equipment would be added to increase nominal capacity. Although some economies of scale could be realized with increased capacity, it was assumed that this equipment would be modular and that the cost of each module would be the same as that used in the 2015 rollout. The same assumptions were made for shipping, installation, design and engineering, and permitting costs. Thus, cost decreases resulting from increased experience with manufacturing this equipment or from technological enhancements were not considered. Station O&M costs were adjusted slightly to account for increases in design capacity. Consistent with the HyPPO scenario assumptions, an annual utilization factor of 80% was used for all stations and all years.

4.2.4 Summary of Cost Assumptions

Table 1 presents the principal assumptions used in the JOBS H2 analysis of the long-term rollout. As before, the total capacity used in the analysis is less than the values reported in the HyPPO document (CaFCP 2014) owing to the assumption that all 28 stations to be added in 2015 have the characteristics of the 19 stations with a 180-kg/day capacity.

TABLE 1 Station Parameters in JOBS H2 Analysis

Year	Operating Stations	Total Capacity at Beginning of Year (kg/day)	Stations Added during Year	Total Capacity Added (kg/day)	Total Development Cost per New Station (1,000 $)
2015	23	3,289	28	5,040	$2,050
2016	51	8,329	8	2,144	$2,050
2017	59	10,473	8	2,000	$2,050
2018	67	12,473	10	3,750	$2,720
2019	77	16,223	10	4,250	$2,720
2020	87	20,473	12	6,000	$3,800
2021	99	26,473	12	6,000	$3,800
2022	111	32,473	12	7,500	$4,470
2023	123	39,973	0	0	NA[a]

[a] NA = not applicable.

Source: CaFCP (2014).

5 REFERENCE SCENARIO RESULTS

Results of the JOBS H2 analysis are summarized below. As noted earlier, these results reflect only those jobs and other benefits that result from expenditures *in California*. In-state expenses include the capital expense of the cascade storage units; the design, permitting and installation of the equipment; the production and delivery of hydrogen; and the operations and maintenance expenses of the refueling stations.

5.1 2015 ROLLOUT ANALYSIS

Estimated results accruing from the 28 stations to be added in 2015 are summarized in Table 2. Note that all benefits from station development (e.g., equipment manufacture and installation, station design, permitting, and construction) accrue during a one-year period, whereas those from hydrogen production and operation of the stations begin to accrue in the first year of operation (assumed to be 2016 in this analysis) and continue as long as the stations operate at the assumed level.

TABLE 2 Economic Benefits to California from 2015 Hydrogen Station Rollout

	Employment (Jobs)			Earnings (Million $)			Economic Output (Million $)		
	Supply Chain	Induced	Total	Supply Chain	Induced	Total	Supply Chain	Induced	Total
Station Development	220	110	330	$12.9	$5.1	$18.0	$39.1	$18.1	$57.2
Station Operation	100	50	150	$5.5	$2.2	$7.7	$21.6	$7.7	$29.3

Employment is expressed in terms of jobs created or supported by the expenditures. A job is defined as one year of work for one person and includes both full-time and part-time work. Earnings consist of wages, salaries, and proprietors' income, with the latter defined as the difference between revenue and explicit production costs in owner-operated businesses. Economic output represents the total value of sales by producing enterprises (including the value of intermediate goods used in production). Gross domestic product is different from gross economic output because the former does not include the value of the intermediate goods used in production.

Supply chain impacts are those directly associated with expenditures on fueling station development and use. These include manufacturing the necessary equipment, installing the equipment and other fueling infrastructure, and operating and maintaining both the equipment and the station itself. Expenditures also include the upstream purchases made by those industries, such as for input materials. In the JOBS H2 model, supply chain impacts are equivalent to what are often referred to as direct and indirect impacts of expenditures.

Induced impacts account for the additional expenditures (on housing, meals, entertainment, etc.) by individuals and households who earn income as a result of supply chain impacts and then re-spend it elsewhere in the economy. As shown in Table 2, between 66% and 74% of the economic benefits of the 2015 rollout are attributable to supply chain impacts.

5.2 LONG-TERM ROLLOUT ANALYSIS

Results for the long-term rollout include benefits from operating the 23 stations reported to be operational in 2015; the 28 stations to be added by the end of 2015; stations added each year from 2016 through 2022; and operating all stations through 2023.

5.2.1 Employment

Employment associated with the development of the new stations is shown in Table 3 and in Figure 1. These jobs will last for one year. Approximately 65% of the station development jobs are attributable to supply chain impacts.

TABLE 3 Employment in California from Developing New H2 Fueling Stations, Long-Term Rollout

	Employment (Jobs)		
	Supply Chain	Induced	Total
2015	220	110	330
2016	60	30	90
2017	60	30	90
2018	100	60	160
2019	100	60	160
2020	120	70	190
2021	120	70	190
2022	160	80	240

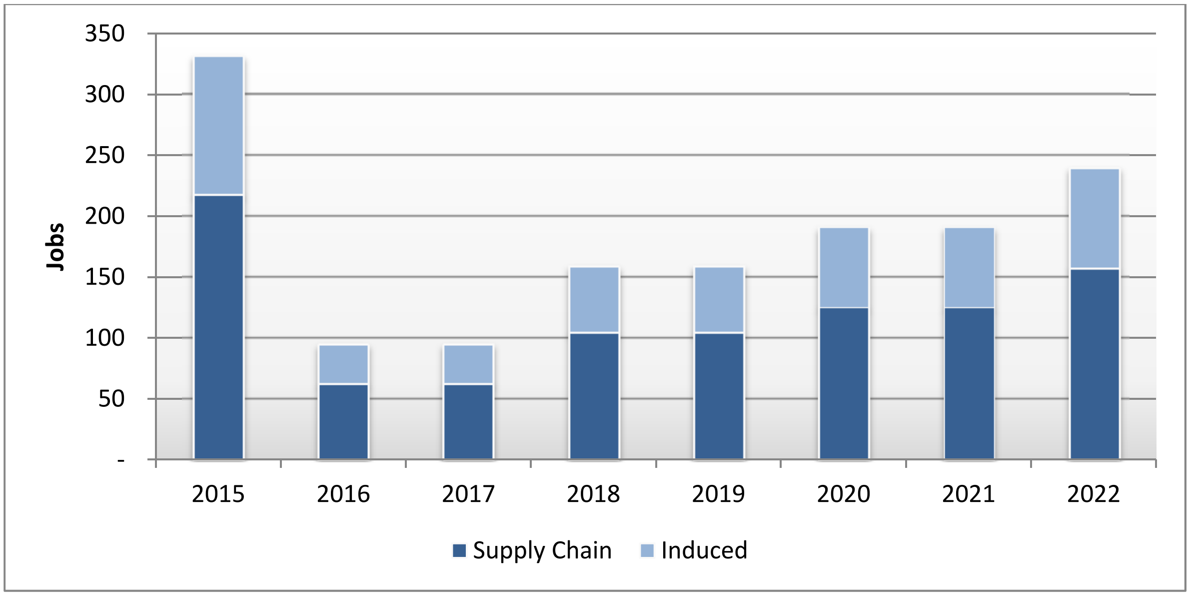

FIGURE 1 Employment in California from Developing H2 Fueling Stations, Long-Term Rollout

Jobs associated with the production of hydrogen, its sale at fueling stations, and station O&M will continue as long as the station continues to operate. The total jobs in California associated with these expenditures are shown in Table 4 and Figure 2. Approximately two-thirds of these jobs are attributable to supply chain impacts. Note that operational jobs from stations developed in year X begin in year X+1.

TABLE 4 Employment in California from Operating H2 Fueling Stations, Long-Term Rollout

	Supply Chain		Induced		Total	
	Beginning of Year	Added during Year	Beginning of Year	Added during Year	Beginning of Year	Added during Year
2015	70	100	30	50	100	150
2016	170	40	80	20	250	60
2017	210	40	100	20	310	60
2018	250	70	120	30	370	110
2019	320	80	150	40	470	120
2020	400	110	190	50	590	160
2021	510	110	240	50	750	160
2022	620	140	290	70	910	200
2023	760	0	360	0	1,120	0

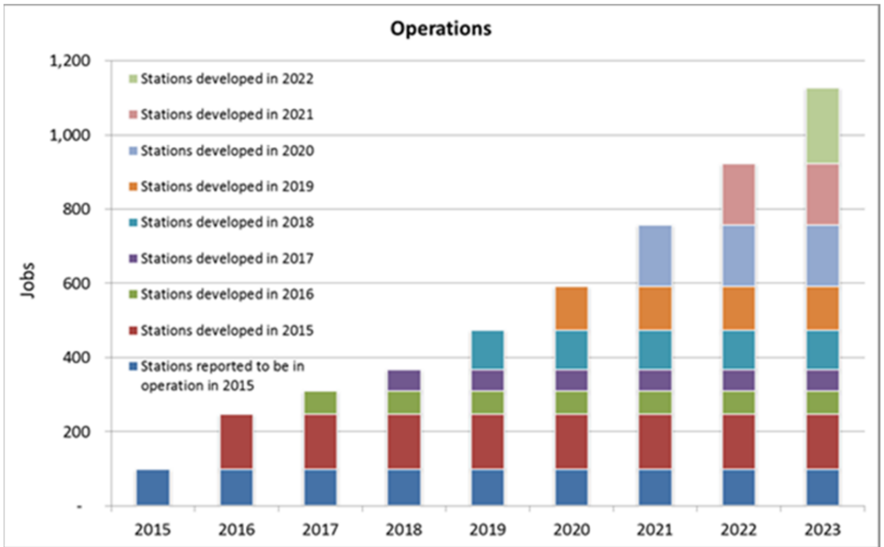

FIGURE 2 Employment in California from Operating H2 Fueling Stations, Long-Term Rollout

5.2.2 Earnings and Economic Output

Like employment, earnings and economic output will accrue from both station development and station operation. While those associated with station development will last for only a single year, those from station operation will continue as long as the stations continue to operate. Total earnings and total economic output are shown in Figures 3 and 4, respectively. As these figures indicate, the economic impact of developing the 28 stations during the 2015 development period is much greater than the impact of operating the 23 stations reported to be operating during 2015. In general, near-term (e.g., one-year) earnings and economic output attributable to the development of new stations exceed annual earnings and output resulting from operating these same stations in subsequent years. The proportion of total impacts from developing new stations decreases with time because of the smaller number of new stations being developed in the latter years of the Road Map (as compared to the 28 stations in 2015) and the increasing population of stations in operation.

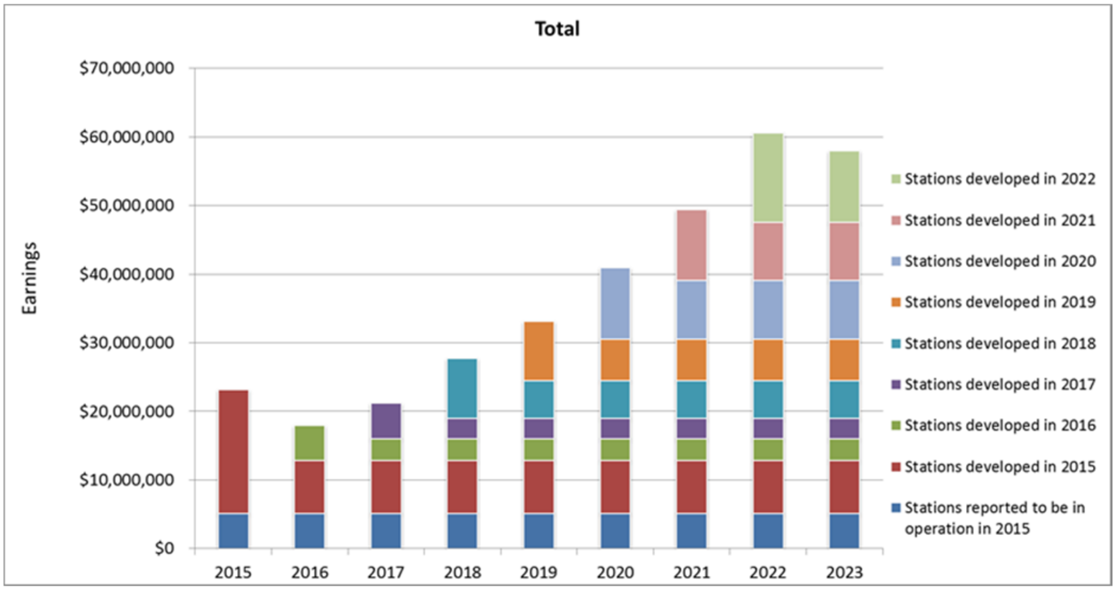

FIGURE 3 Earnings in California from Developing and Operating H2 Fueling Stations, Long-Term Rollout

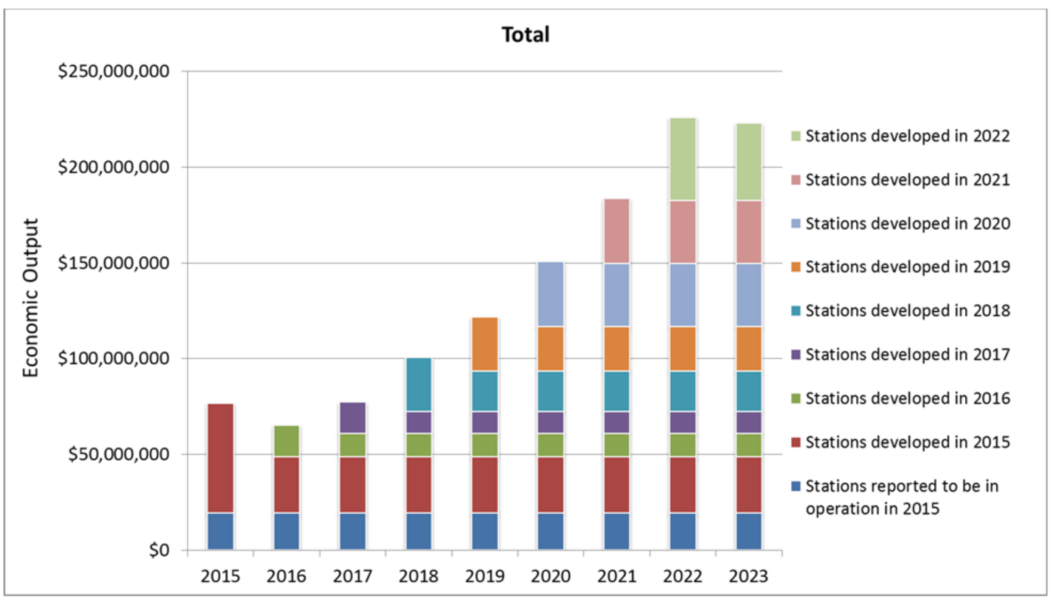

FIGURE 4 Economic Output in California from Developing and Operating Hydrogen Fueling Stations, Long-Term Rollout

As noted earlier, a basic assumption in this analysis is that once a station becomes operational, it will continue to operate at the given level for the entire period of interest. In reality, this assumption may not be valid in the long term for a variety of potential reasons, including equipment malfunction or failure, unrealized economic viability, etc. Any impacts associated with the *development* of such stations would have already occurred; thus, decreased operation would not affect (or undo) these impacts. However, decreased operation could have a substantial effect on operational impacts, which may or may not be mitigated. If lost hydrogen sales from one station were picked up by other stations, the difference in total impacts would be expected to be small because impacts from hydrogen production and delivery would be unchanged, and impacts from station operation and maintenance would likely decrease only marginally. However, if lost hydrogen sales were not picked up by other stations, fewer FCEVs would be supported and/or the utilization of those supported would decline. These latter possibilities were beyond the scope of this analysis.

6 “ALL WITHIN CALIFORNIA” CASE

As discussed above, this analysis assumed that the cascade storage units were the only pieces of major equipment manufactured in California. This assumption was based on information presented in the proposal for the 19 stations of the same design and is consistent with the relatively small manufacturing base currently in California. As a way of bounding the resulting estimates of economic benefits from the California rollout and to illustrate some of the potential economic impacts from an expanded manufacturing base, another set of estimates was developed in which it was assumed that all equipment was manufactured in California. With this assumption, *all expenditures associated with the development and operation of the hydrogen fueling stations occur in California and thus all benefits accrue within the state*. In terms of model input, running the “All Within California” case meant that all expenses were specified as having a 100% local share.

6.1 EMPLOYMENT

Employment results for the “All Within California” Case are shown in Table 5 and Figure 5. Comparing the results in Table 5 with those in Table 3 suggests that should all equipment be manufactured in California, employment impacts in the state could increase by 100% or more. Note that the station development impacts shown in Table 2 included those from design, permitting, and installation of the equipment. Although the “All Within California” Case is perhaps unlikely to occur, it does indicate the significance of local manufacturing capabilities in the development of hydrogen fueling stations.

TABLE 5 Employment Resulting from Station Development, “All Within California” Case

	Employment (Jobs)		
	Supply Chain	Induced	Total
2015	440	230	670
2016	120	70	190
2017	120	70	190
2018	200	110	310
2019	200	110	310
2020	330	180	510
2021	330	180	510
2022	390	210	600

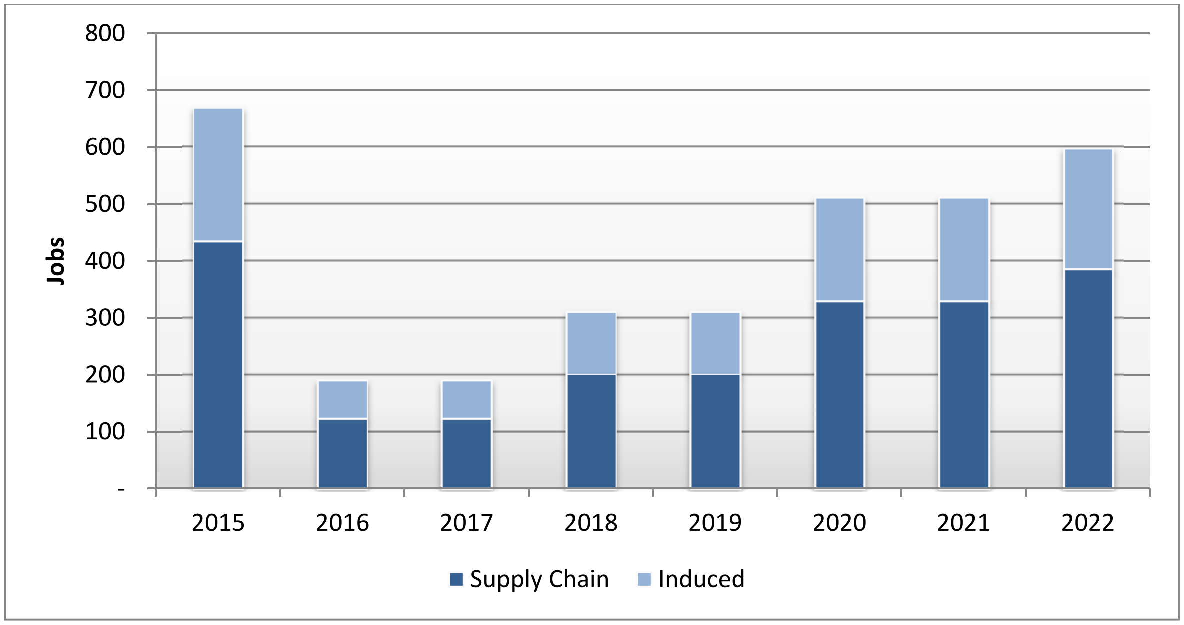

FIGURE 5 Station Development Employment, "All Within California" Case

For station operations, however, within-region assumptions exert a much smaller influence. Under the "All Within California" Case, there are no additional employment impacts resulting from station operations because the Reference Scenario analysis (in Section 5) already assumed that the hydrogen would be produced in California and that all expenses associated with the operation and maintenance of the stations would also occur in California.

6.2 TOTAL EARNINGS AND TOTAL ECONOMIC OUTPUT

Impacts on total earnings and economic output for the "All Within California" Case are shown in Figures 6 and 7, respectively. Increases in total earnings and total economic output are not as significant as for employment because of the increasing influence of operating stations, which already were assumed to have 100% of expenditures occurring within California in the Reference Scenario's analysis. Note that total earnings and total economic output for the year 2023 are the same as for the Reference Scenario because there are no new stations being developed during that year; thus, all impacts are attributable to the operation of existing stations.

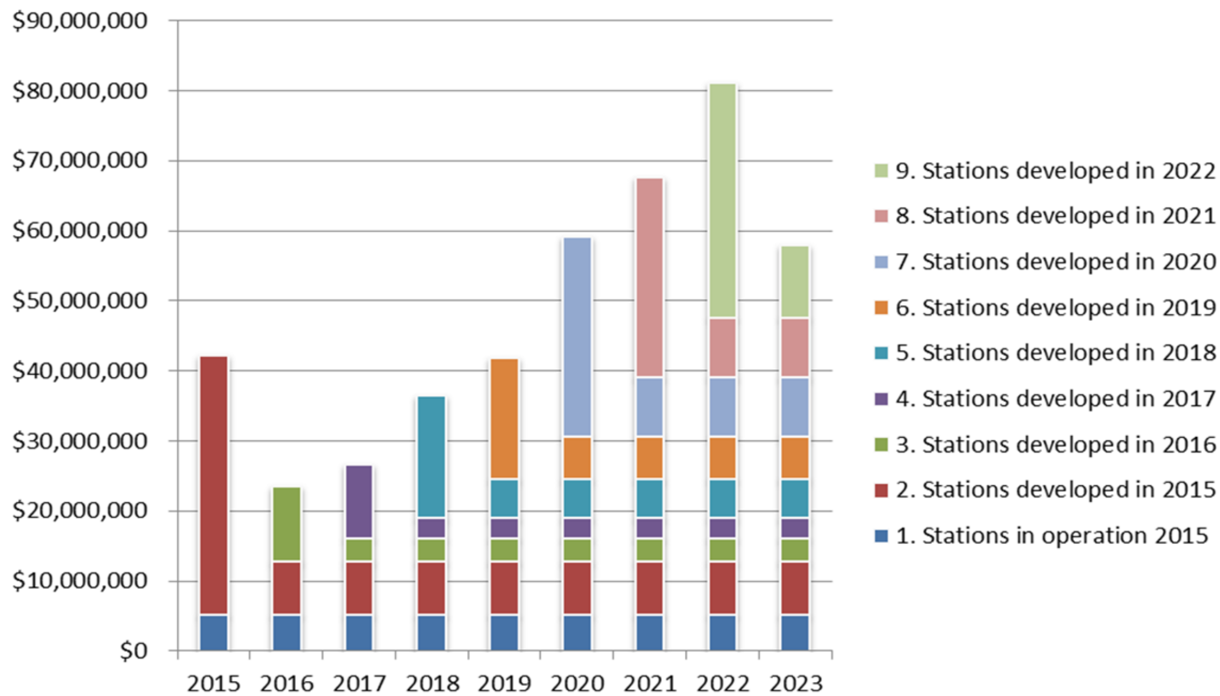

FIGURE 6 Total Earnings Impact under the **"All Within California" Case**

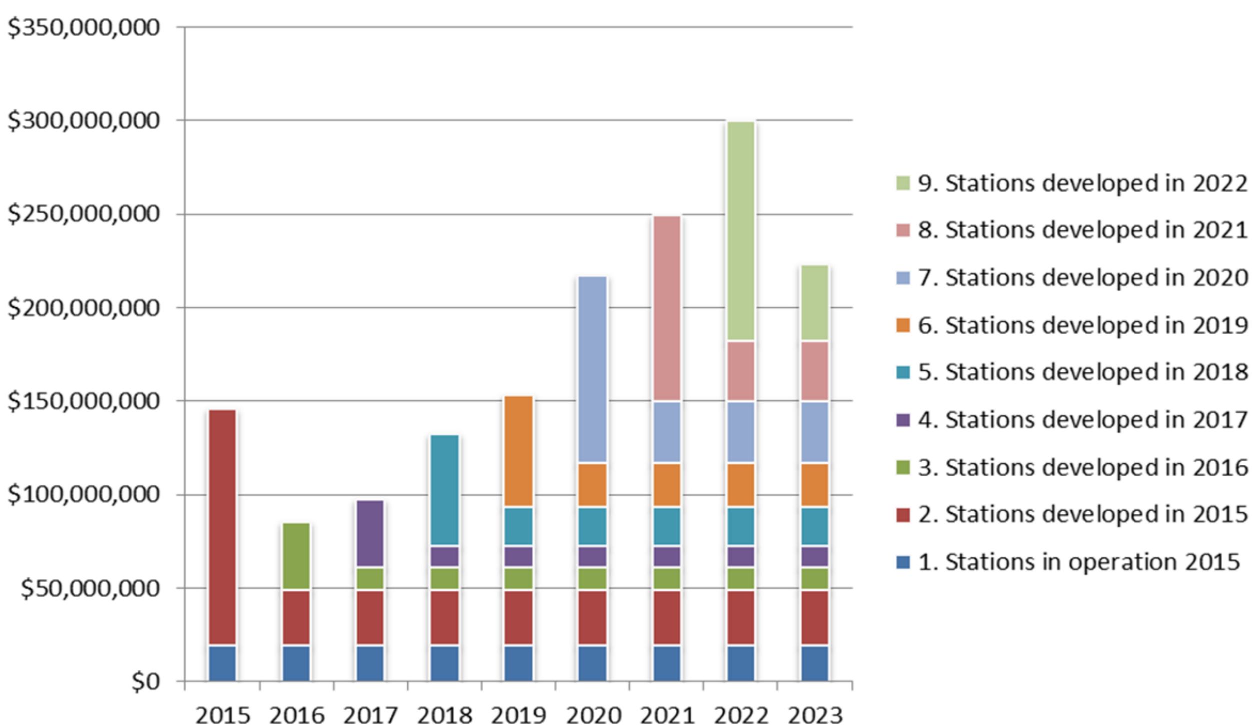

FIGURE 7 Total Economic Output Impact under the "All Within California" Case

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7 CONCLUSIONS

7.1 REFERENCE SCENARIO

Results obtained from the analyses conducted with the JOBS H2 model are reported in terms of jobs supported or created and total earnings and economic output resulting from expenditures from designing, constructing, and operating hydrogen fueling stations. The Reference Scenario (or Base Case) analysis was based on the assumption that the only piece of major equipment manufactured in California was the cascade storage system. Under this assumption, the number of jobs supported or created by station development was estimated at 330 jobs in 2015 (Table 3). These jobs would be of a one-year duration. The number of station development jobs would decrease to about 90 in 2016 because of the smaller number of stations expected to be developed in that year, and then rise with increasing station development to a peak of 240 jobs in 2022.

Jobs associated with operating and maintaining the 23 hydrogen fueling stations reported to be operational in 2015 were estimated at 100. The number of such jobs would increase over the time frame of interest, reaching approximately 1,130 in 2023 (Table 4) when a total of 123 hydrogen fueling stations are expected to be in operation. Unlike the station development jobs, these jobs continue as long as the stations operate at the assumed utilization rate.

Earnings in California under Reference Scenario assumptions were estimated to range from approximately $18 million in 2016 to $60 million in 2022 (Figure 3). These figures include annual earnings from station development during a given year, as well as earnings from stations that are in operation during the year.

7.2 "ALL WITHIN CALIFORNIA" CASE

If it is assumed that all major pieces of equipment will be manufactured in California, the number of in-state jobs associated with station development will increase by 100% or more (Table 5) over the Reference Scenario (Table 3). By contrast, jobs attributable to the production of hydrogen and the operation and maintenance of stations do not exhibit this pattern because the Reference Scenario already assumed that all hydrogen dispensed at these stations was produced in California and that all operating and maintenance expenses were incurred in California. Likewise, employment, earnings, and economic output associated with station operation under the "All Within California" Case are no different from those under the Reference Scenario.

As a whole, however, total earnings under the "All Within California" Case rise by approximately $4 million in 2016 and $20 million in 2022 (Figure 6) as compared with the Reference Scenario (Figure 3). Similarly, total economic output rises by approximately $20 million in 2016 and $70 million in 2022 (Figure 7) as compared with comparable figures for the Reference Scenario (Figure 4). Although earnings and output estimates are higher for the

"All Within California" Case, the percentage increase over the Reference Scenario is less dramatic than for employment estimates. This result occurs because, even in the Reference Scenario, all hydrogen production costs and all costs associated with the operation and maintenance of hydrogen fueling stations were already assumed to occur in California.

8 REFERENCES

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APPENDIX A: ANALYSIS OF POTENTIAL DELAYS IN STARTING OPERATIONS FOR HYDROGEN REFUELING STATIONS IN CALIFORNIA

Undocumented information recently available to the authors suggests that there may be delays in implementing the operations of some of the stations that planners had originally assumed would be operational by January 1, 2015. This operational status was a basic assumption in the analysis presented in the main body of the current report. Furthermore, it has been suggested that the development period for new stations is likely to be longer than the one-year period described in the Reference Scenario's station proposal and assumed in the analysis. To address the effects of these situations, a supplemental analysis was conducted in which the operational status of the initial 23 stations was altered and the development period for new stations was increased to two years. Because the JOBS H2 model works on a calendar year basis, it was assumed that the design and permitting of new stations occurs in year one of the development period and that equipment manufacture and installation occur in year two.

The revised station schedule considered in this alternate scenario is shown in Table A1. As noted in the table, the initial year in this analysis is 2014 instead of 2015. This change was made because recent information suggests that a two-year development period is appropriate and some stations will begin operations in 2016, thus suggesting that expenditures and corresponding economic impacts began in 2014.

TABLE A1 Station Parameters in Alternate Development Scenario

Year	Operating Stations at Beginning of Year	Total Capacity at Beginning of Year (kg/day)	Stations Added during Year	Total Capacity Added during Year (kg/day)	Total Development Cost per New Station (1,000 $)
2014	9	963	3	600	–
2015	12	1,563	39	6,766	$2,050
2016	51	8,329	8	2,144	$2,050
2017	59	10,473	8	2,000	$2,050
2018	67	12,473	10	3,750	$2,720
2019	77	16,223	10	4,250	$2,720
2020	87	20,473	12	6,000	$3,800
2021	99	26,473	12	6,000	$3,800
2022	111	32,473	12	7,500	$4,470
2023	123	39,973	0	0	NA

NA = Not applicable.

The data in Table A1 reflects the following information:

- As of mid-2014, there were nine operational stations in California;
- Three additional stations were expected to become operational in late 2014;
- Eleven stations currently under development (under previous awards) may be delayed until late 2015 and become operational by January 1, 2016;
- The 28 stations that received awards in 2014 are expected to be operational by January 1, 2016; and
- All other stations noted in the 2014 Hydrogen Progress, Priorities, and Opportunities (HyPPO) report are expected to be operational by January 1 of the appropriate year.

A.1 ALTERNATE 2015 ROLLOUT SCENARIO

The only difference between this analysis and the Reference Scenario is that the development time for the 28 new stations is two years rather than one year. Impacts resulting from station development are shown in Table A2 for each of the two development years. Recall that during the first year of development, the station design and permitting are completed, whereas in the second year, impacts of equipment manufacture and station construction are determined. Impacts resulting from station operation are not shown here as they are the same as in the Reference Scenario (Table 2).

TABLE A2 Economic Benefits to California from Station Development in Alternate 2015 Hydrogen Station Rollout Scenario

	Employment (Jobs)			Earnings (Million $)			Economic Output (Million $)		
	Supply Chain	Induced	Total	Supply Chain	Induced	Total	Supply Chain	Induced	Total
Year 1	40	20	60	$2.4	$1.0	$3.4	$6.6	$3.4	$10.0
Year 2	180	90	270	$10.5	$4.1	$14.6	$32.5	$14.7	$47.2

A.2 ALTERNATE LONG-TERM ROLLOUT SCENARIO (ALTERNATE SCENARIO)

Annual employment under the Alternate Scenario differs from employment under the Reference Scenario because of two factors: First, the delay in the original 23 stations will show employment benefits during the period of interest. Second, the two-year development period for each station will spread employment impacts over two years instead of one.

Employment resulting from station development under the Alternate Rollout Scenario is shown in Figure A1. As before, the initial year of 2014 is used in this scenario because a portion of development expenditures occurred in that year. However, as noted above, expenditures are spread over two years and, for some of the stations, station development is delayed under this scenario.

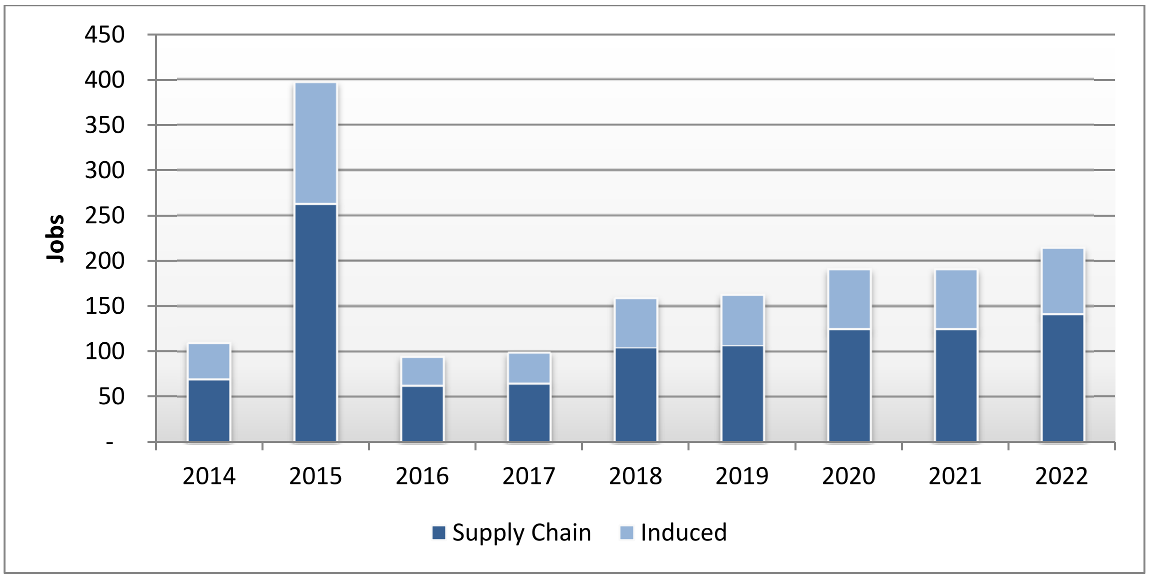

FIGURE A1 Employment because of Station Development: Alternate Long-Term Rollout Scenario

As evident in this figure, development employment peaks in 2015 because of both the large number of stations expected to become operational by January 1, 2016, and the initial development activities for stations expected to become operational by January 1, 2017.

The year-by-year employment that results from operating the hydrogen refueling stations differs from the Reference Scenario because of the change in schedule for the initial 28 stations. Results for the Alternate Scenario are shown in Figure A2. Comparing Figure A2 with Figure 2 shows that initial operations employment will be smaller in the Alternate Scenario; however, once all of the initial 23 stations become operational, employment will be the same in the two scenarios.

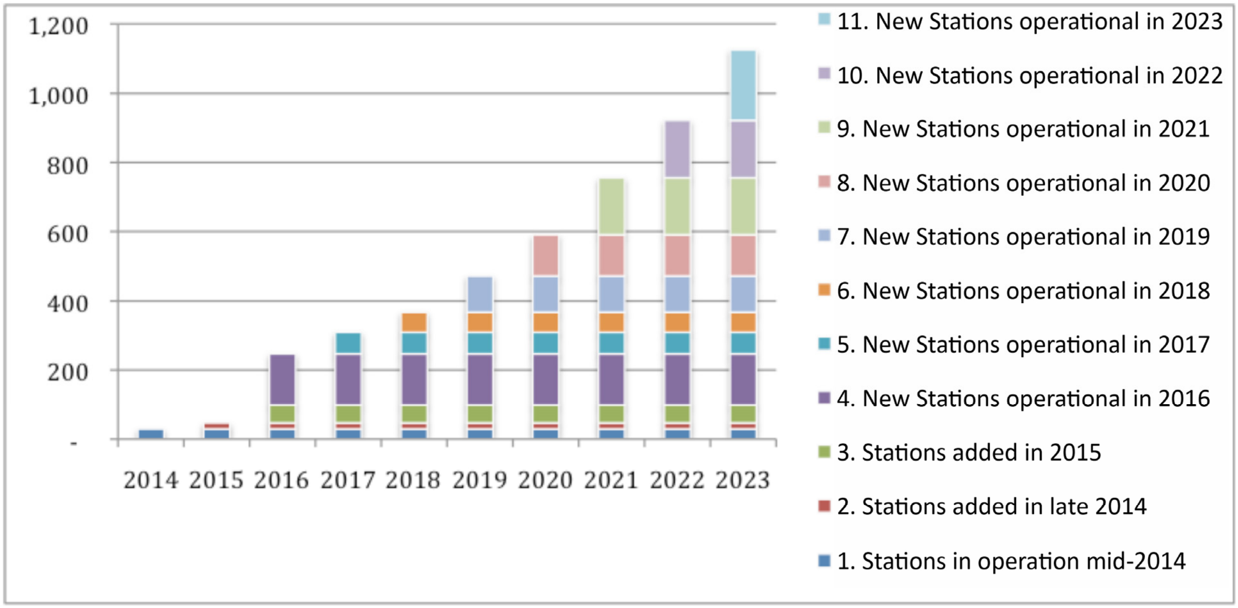

FIGURE A2 Employment in California from Operating H2 Refueling Stations: Alternate Long-Term Rollout Scenario

Figures A3 and A4 show the combined development and operations projections for earnings and economic output, respectively, for the Alternate Rollout Scenario. These figures differ only slightly from those of the Reference Scenario because of the delay in starting station operations and the two-year development time for new stations.

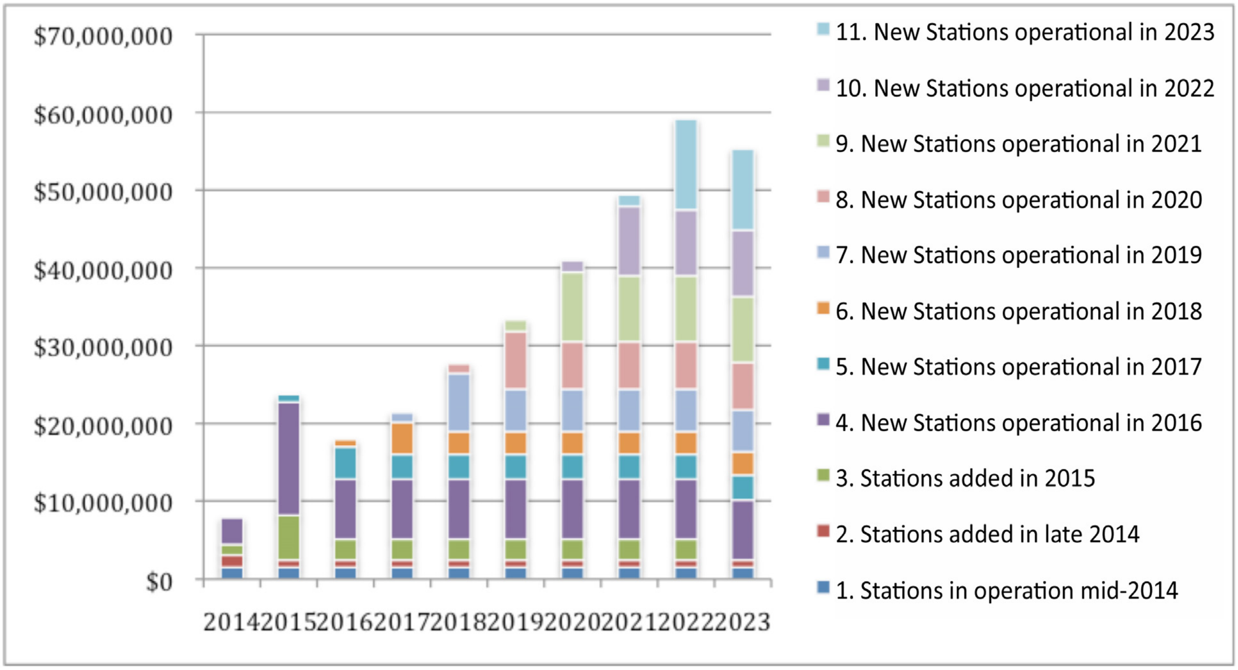

FIGURE A3 Earnings from Developing and Operating Stations: Alternate Long-Term Rollout Scenario

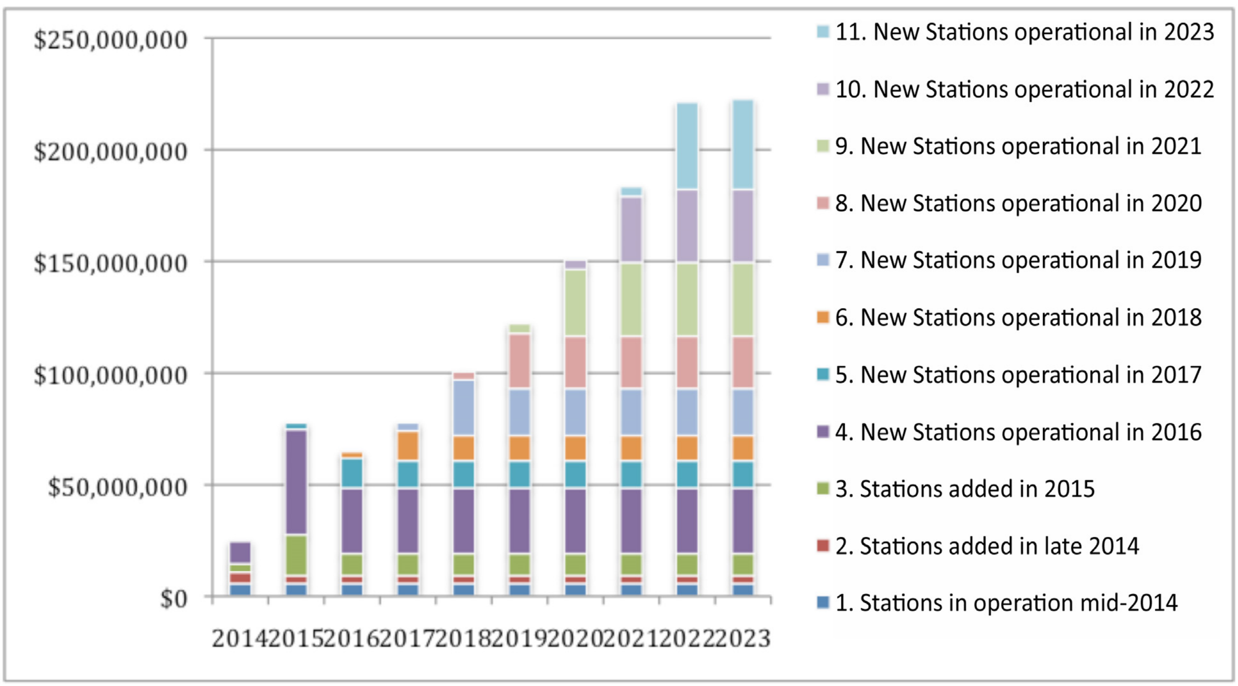

FIGURE A4 Economic Output from Developing and Operating Stations: Alternate Long-Term Rollout Scenario

A.3 "ALL WITHIN CALIFORNIA" ALTERNATE ROLLOUT SCENARIO

Employment related to station development for the "All Within California" Alternate Scenario is shown in Figure A5.

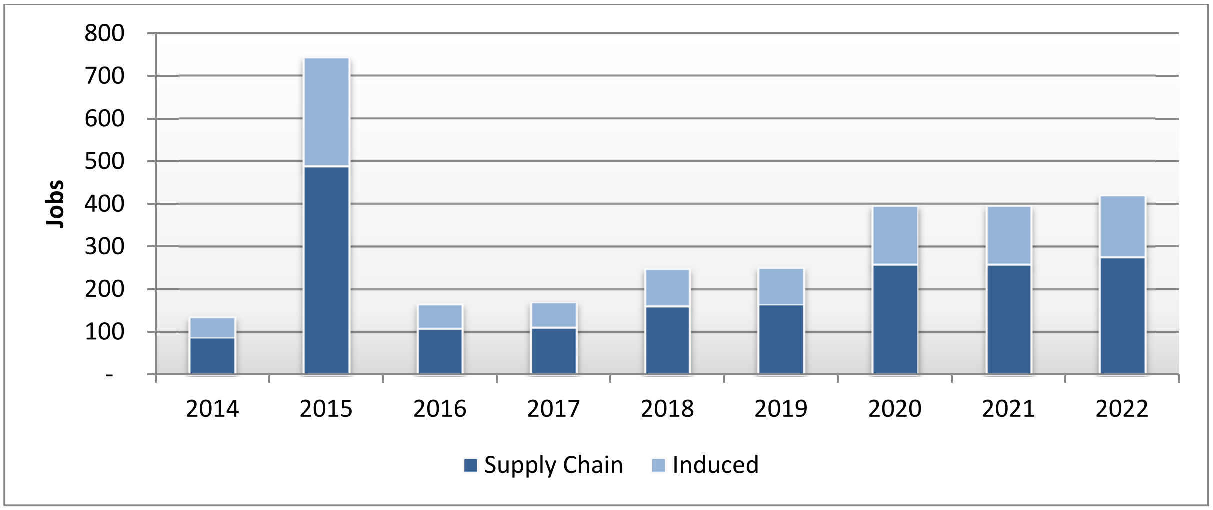

FIGURE A5 Station Development Employment, "All Within California" Alternate Rollout Scenario

Comparison of Figure A5 with Figure A1 shows that in the early years, the potential increase in employment is somewhat less than the 100% increase noted under the Reference Scenario (Figure 1). A similar percentage increase is evident in the later years.

Results for earnings and economic output are not shown here, as impacts are very similar to those shown in the Reference Scenario (Figures 3 and 4). As noted above, the influence of operating stations on total earnings and output become greater as more stations become operational. Furthermore, there is no difference in within-California operational expenditures between the two cases.

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