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Economic Benefits of a Comprehensive Feed-In Tariff:

An Analysis of the REESA in California

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Summary of Benefits

In this analysis we estimate that the Feed-In Tariff (FIT) enacted by the Renewable Energy and Economic Stimulus Act (REESA) will have a range of economic benefits to the state of California over the next decade versus a "business-as-usual" scenario of renewable energy supply. We find that the Feed-In Tariff will:

- Create three times the number of jobs from 2011-2020. This equates to generating about 280,000 additional direct job-years or 28,000 job-years on average per year from 2011-2020 with an additional 27,000 indirect and induced jobs per year. More jobs are generated in the first part of the decade than in later years.
- Increase direct state revenues by an estimated $1.7 billion from sales tax, use tax, and income taxes over the next decade and estimated induced revenues of about $600 million from increased employee compensation and the impact of FIT program costs. This does not include any savings to the state in avoided unemployment benefits.
- Stimulate up to $50 billion in total new investment in the state which in turn is eligible for up to $15 billion in Federal tax benefits for project developers.

As a result the REESA FIT provides a highly cost-effective avenue to assist in the state's efforts to achieve the 33% Renewable Portfolio Standard (RPS) target by 2020.

Introduction

The REESA is a legislative proposal for California that institutes a statewide Feed-In Tariff (FIT), or a pre-specified electricity price paid to mid-sized clean energy distributed generation installations (1-20 MW) with rates set commensurate with the projected cost of generation. Well-designed FIT programs are acknowledged to be the lowest cost way to reduce greenhouse emissions (GHG) in the power sector and have successfully promoted clean energy investment, wide spread industrial development and higher employment (LABC 2010).

FIT programs "level the playing field" for developers, since the FIT price is specified for years while the streamlined development process further reduces barriers and costs. Furthermore, the REESA fills a gap in the current regulatory structure with the California Solar Initiative (CSI) and Small Generator Incentive Program (SGIP) covering smaller installations up to 1MW, and the existing RPS program targeted at larger installations greater than 20 MW. This is illustrated in Figure 1.

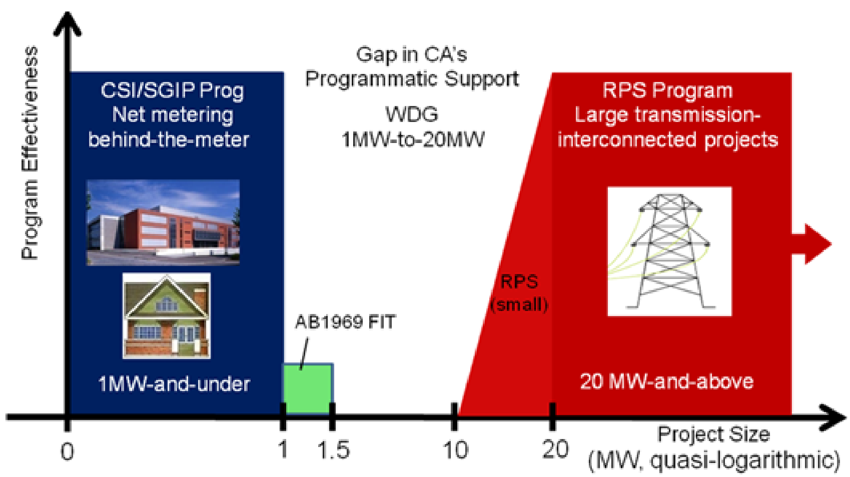

Figure 1. Schematic of current California state programs for solar electricity showing the gap in programmatic support for wholesale distributed generation (WDG) in the intermediate project size regime from approximately 1-20MW.

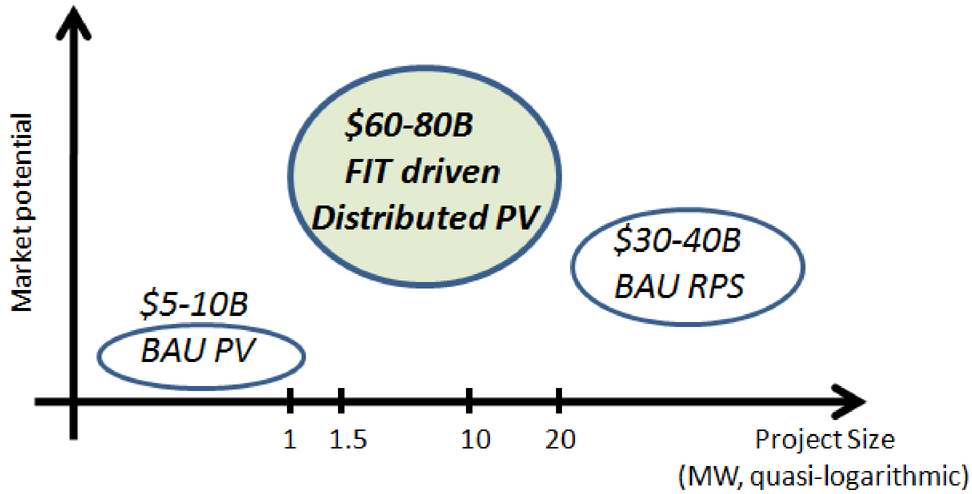

Figure 2. Market size in new solar electric generation development versus project sizes. Small (<1MW) and large (>20MW) estimates are based on business as usual (BAU) CARB projections while FIT driven distributed PV (between 1 and 20MW) estimate is based on projections from this work.

At present the state's RPS will fall well short of the 20% target for 2010. Currently, the state gets 13% of its energy from renewable sources, thus needs another 20% to come from renewable sources to reach the RPS goal of 33%-by-2020. To energize the clean energy market, and meet the next goal of 33%-by-2020, wholesale distributed generation (WDG) offers an excellent mechanism to build a cost-effective job-generating market because it can be implemented rapidly and builds market certainty. Power from distributed generation sources benefit from being able to tap directly into the existing transmission system without the need for new transmission line construction. Distributed generation power supply sources are commonly solar photovoltaic (PV) installations, but can also be wind, biogas, biomass, and geothermal supply sources. Without price and regulatory certainty over several years, developers lack the incentive to build distributed solar PV installations in this size range. Current "behind-the-meter" retail solar PV under the CSI/SGIP is unable to reach large volumes of energy production since installations are small and solar PV has not been able to contribute much to the state's aggressive RPS targets. Moreover, programs such as the CSI subsidize wealthy ratepayers that can afford solar and can be difficult to implement in some applications (e.g. multi-unit housing).

The proposed FIT will stimulate very significant in-state investment in WDG. Significantly more jobs and greater tax revenues are projected than a business-as-usual renewable energy supply case since in the WDG case, virtually all economic activity (production and distribution of energy) remains in the state. Estimated market potential is shown in Figure 2 for new solar electric generation. Small (<1MW) and large (>20MW) project size estimates are based on business as usual (BAU) CARB projections while "FIT driven distributed PV" (between 1 and 20MW) based on projections from this work has the potential to unlock up to two times the investment of the BAU path with the existing regulatory framework.

The FIT proposal is fully consistent with the state's historical support of leading edge energy programs and would strengthen the state's portfolio of clean energy policies. Innovative new financing programs such as property assessment clean energy (PACE) are targeted primarily at residential and small commercial installations and FIT would be an effective policy tool to address medium scale, commercial development projects.

We provide a background discussion of distributed generation and solar PV below followed by discussion on state electricity demand scenarios, employment calculations, and revenues to the state. The modeling approach here is to consider an aggressive deployment of distributed generation solar PV as a bounding case for distributed generation since currently solar PV has the highest installed cost among leading renewable energy technologies (biomass, geothermal, solar thermal and wind).

Background

Solar PV has both a higher capital cost per peak kW – though rapidly falling – and a lower capacity factor than other renewable energy sources. Thus to generate the same amount of annual energy as other renewable energy sources, higher investment amounts are required in the first few years of the decade. This will lead to higher employment from the construction, installation and manufacturing sectors that are required for a large solar build out. This large surge in employment will be counteracted to a certain degree by ratepayers having to pay higher electricity bills initially and having a lower level of disposable income, resulting in less employment from consumer spending. Higher revenues to the state in the form of sales tax (or use tax) and income tax are expected from the larger investment required for solar PV supplied electricity. The incremental additional cost of Solar PV provided electricity to California ratepayers are mitigated by three factors: (1) federal incentives to producers; (2) favorable time of day (TOD) valuation for solar energy; and (3) rapid technological progress and learning in the solar industry. The TOD valuation stems from the fact that solar PV produces power at times close to maximal system demand and thus has more value than power produced during off peak times.

It is important to understand the REESA FIT proposal in the context of other studies on solar PV cost effectiveness. Previous studies (Vermont 2009) on feed in tariffs applied to a wide variety of renewable sources observed a large increase in employment initially, but this was counteracted by some employment reductions in later years due to higher costs for alternative energy supplies with the net result of a small positive employment impact. The key point is that a favorable balance of employment can be achieved if the levelized costs of renewable energy alternatives are comparable to or not much more than the "avoided" costs of incumbent supply sources; and the levelized cost of solar PV has dropped dramatically in the past year. Renewable energy sources such as biomass, solar PV, and wind also benefit from providing more jobs per dollar invested than traditional energy sectors in the economy since coal and natural gas plants are not as labor intensive, so moving investment toward renewable energy as well as energy efficiency produces net employment since these investments are more labor intensive.

Borenstein (2008) reported that Solar PV is too expensive based on a careful cost study of levelized cost of energy versus the value of generated power. However this study focused on residential systems and residential installed costs in 2007-2008 were much higher than current costs for 1-20MW sized distributed PV due to silicon supply shortages and lack of project scale. The author also highlights the fact that renewable energy policy is rarely structured to exploit the distribution and transmission benefits of distributed PV. The report does not consider federal incentives with a focus on assessing the economic merits of unsubsidized renewable energy.

In contrast, the REESA FIT targets medium scale commercial installations where costs have dramatically fallen in the past year (20-30% below the costs of current residential solar). It is specifically designed to exploit the distribution and transmission benefits of distributed power. Further, for the purposes of this California state study, we include the impacts of federal incentives on clean energy costs.

FIT economic modeling

Employment is determined by an output-based model including incremental costs to ratepayers, and revenue is estimated based on the investment requirements relative to a business-as-usual case of renewable energy supply assuming a 33% RPS target in 2020. The FIT build out assumes all additional renewable resources required for a 33% RPS are provided by distributed solar PV – a worst case cost scenario. The business-as-usual reference case is the California Air Resources Board (CARB) 33% scenario based on increased generation by geothermal, solar thermal and wind technologies (CARB-E3 2010).

In reaching these conclusions, we considered two cases based on work at the CARB: a low load case and a high load case that differ based on the amount of Combined Heat and Power (CHP) and energy efficiency implemented by 2020. The FIT rate starts at $0.16 / kWh in 2011 and decrements to $0.10 / kWh in 2020, based on a National Renewable Energy Lab (NREL) cost model for solar PV. The avoided cost is taken as the Market Price Referent (MPR) as defined by the CPUC with Time-of-Day (TOD) adjustments for peak solar PV power output (CPUC-E3 2009, CAL SEIA 2010). Installed costs for renewable energy sources are taken from 2009 CEC estimates (Klein 2010), the NREL-Solar Advisor Model (NREL-SAM 2010), and market estimates.

Low Load Scenarios

The low load scenarios have 250,000 GWh RPS eligible electricity output in 2020 after accounting for 30,000 GWh of new CHP capacity and 2000 GWh of new behind-the-meter solar, which is not included in the RPS-eligible load as assumed in the CARB memo. This case also includes 24,000 GWh electricity savings from expanded energy efficiency programs. "In-state %" represents the fraction of output that is provided in-state, based on CEC 2009 data. We provide two reference cases:

> [I] The "CARB Ideal 33% RPS low load reference" assumes that the 2020 RPS reference targets are achieved and that high degrees of domestic generation are achieved for solar thermal (97%) and wind (78%).
>
> [II] The "CARB Realistic 33% RPS low load" reference. Two adjustments have been made for the realistic case: (1) the out of state fraction of electricity is assumed to increase for solar thermal and wind (90%, 60% in-state respectively); and (2) the 33% target is not to be achieved and has been de-rated to 27% in 2020 with the remaining 6% to be covered by purchased RECs. This assumption is made since the state has not been able to meet its existing RPS targets and due to the recent CPUC ruling accepting unbundled and tradable RECs (TRECs). The reference RPS case has a greater reliance on centralized power stations which are subject to longer lead times, greater requirements for new transmission lines, and thus more project construction delays and project risk. Purchased RECs are assumed to be priced at $0.035/kWh.

The 33% FIT scenario represents aggressive increase of solar PV distributed generation. Existing levels of production for other renewable technologies (biomass, geothermal, small hydro, solar thermal and wind) are assumed to be maintained at 2009 levels, while solar PV is ramped aggressively to about seven times the 2020 reference level, with large reductions in geothermal, solar thermal and wind production relative the reference scenario. The level of solar PV in 2020 is initially taken as 20% of the estimated total load at 250,000 GWh or 50,000 GWh in 2020 and is then adjusted to account for non-decreasing production level for other renewable sources.

Under this scenario, domestic production of natural gas fired electricity, coal, large hydro, and nuclear are held flat from 2010 to 2020 with a large reduction in imported electricity. To first order, all employment differentials from 2009 are due to increasing renewable production, and all employment changes from the 2020 reference cases to the 2020 FIT case are due to shifts in the mix of renewable energy sources. Renewable generation increases from an estimated 40 GWh in 2010 to 82 GWh in 2020.

				ARB 4/5/10 - 33% RPS ideal lo-load scenario				FIT 33% lo load scenario			
	2009	2009	2009								
	est GWh	In State GWh	Imported GWh	GWh	% In state	In State GWh	Imported GWh	GWh	% In state	In State GWh	Imported GWh
N. Gas	138,813	120,994	17,819	127,418	95%	120,994	6,424	127,536	95%	120,994	6,542
Coal	55,271	3,937	51,333	38,500	10%	3,937	34,563	37,800	10%	3,937	33,863
Large Hydro	33,396	20,830	12,566	30,654	68%	20,830	9,825	30,683	68%	20,830	9,853
Nuclear	43,825	32,158	11,668	40,228	80%	32,158	8,070	40,265	80%	32,158	8,108
RPS Eligible											
Biomass/ Wood	7,480	6,709	771	10,507	90%	9,456	1,051	7,480	90%	6,732	748
Geothermal	13,662	12,907	755	23,253	95%	21,974	1,279	13,662	95%	12,911	751
Solar PV	702	702	-	6,471	100%	6,471	-	43,500	100%	43,500	-
Solar Thermal	1,446	1,403	43	13,532	97%	13,126	406	1,446	97%	1,402	43
Small Hydro	4,416	3,729	687	4,417	84%	3,710	707	4,416	84%	3,709	707
Wind	11,794	9,209	2,585	24,175	78%	18,857	5,319	11,794	78%	9,199	2,595
Tot RPS	39,499	34,659	4,841	82,355		73,594	8,761	82,297		77,453	4,844

Table 1. Low Load demand scenario for 33% RPS ideal reference and FIT 33% case.

	2009	2009	2009								
	est GWh	In State GWh	Imported GWh	GWh	% In state	In State GWh	Imported GWh	GWh	% In state	In State GWh	Imported GWh
N. Gas	138,813	120,994	17,819	141,418	86%	120,994	20,424	127,536	95%	120,994	6,542
Coal	55,271	3,937	51,333	38,500	10%	3,937	34,563	37,800	10%	3,937	33,863
Large Hydro	33,396	20,830	12,566	30,654	68%	20,830	9,825	30,683	68%	20,830	9,853
Nuclear	43,825	32,158	11,668	40,228	80%	32,158	8,070	40,265	80%	32,158	8,108
RPS Eligible											
Biomass/ Wood	7,480	6,709	771	8,616	90%	7,754	862	7,480	90%	6,732	748
Geothermal	13,662	12,907	755	19,067	95%	18,019	1,049	13,662	95%	12,911	751
Solar PV	702	702	-	5,306	95%	5,041	265	43,500	99%	43,065	435
Solar Thermal	1,446	1,403	43	11,096	90%	9,987	1,110	1,446	90%	1,301	145
Small Hydro	4,416	3,729	687	4,417	84%	3,710	707	4,416	84%	3,709	707
Wind	11,794	9,209	2,585	19,824	60%	11,894	7,929	11,794	60%	7,076	4,718
Tot RPS	39,499	34,659	4,841	68,326		56,405	11,921	82,297		74,794	7,503

Table 2. Low Load demand scenario for 33% RPS realistic reference and FIT 33% case.

High Load Scenarios

The high load case has 290,000 GWh of RPS eligible electricity output in 2020 after accounting for 15,000 GWh of new CHP capacity, and 1,000 GWh of new behind the meter solar, which is not included in the RPS-eligible load as assumed in the CARB memo. As above we provide two reference cases:

> [I] The "CARB Ideal 33% RPS high load reference" assumes that the 2020 RPS reference targets are achieved and that high degrees of domestic generation are achieved for solar thermal (97%) and wind (78%).
>
> [II] The "CARB Realistic 33% RPS high load" reference. Two adjustments have been made for the realistic case: (1) the out of state fraction of electricity is assumed to increase for solar thermal and wind (90%, 60% in-state respectively); and (2) the 33% target is not to be achieved and has been de-rated to 27% in 2020 with the remaining 6% to be covered by purchased RECs. This assumption is made since the state has not been able to meet its existing RPS targets and due to the recent CPUC ruling accepting unbundled and tradable RECs (TRECs). The reference RPS case has a greater reliance on centralized power stations which are subject to longer lead times, greater requirements for new transmission lines, and thus more project construction delays and project risk. Purchased RECs are assumed to be priced at $0.035/kWh.

The 33% FIT scenario represents aggressive increase of solar PV distributed generation. Existing levels of production for other renewable technologies (biomass, geothermal, small hydro, solar thermal and wind) are assumed to be maintained at 2009 levels, while solar PV is ramped aggressively to about eight times the 2020 reference level, with large reductions in geothermal, solar thermal and wind production relative the reference scenario. The level of solar PV in 2020 is initially taken as 20% of the estimated total load at 290,000 GWh or 58,000 GWh and is then adjusted to account for non-decreasing production level for other renewable sources.

Under this scenario, domestic production of natural gas fired electricity, coal, large hydro, and nuclear are held flat from 2010 to 2020 with some reduction in imported electricity. To first order, all employment differentials from 2009 are due to increasing renewable production, and all employment changes from the 2020 reference cases to 2020 FIT case are due to shifts in the mix of renewable energy sources. Renewable generation increases from an estimated 40 GWh in 2010 to 95 GWh in 2020.

				ARB 4/5/10 - 33% RPS ideal high-load scenario				FIT 33% hi load scenario			
	2009 est GWh	2009 In State GWh	2009 Imported GWh	GWh	% In state	In State GWh	Imported GWh	GWh	% In state	In State GWh	Imported GWh
N. Gas	138,813	120,994	17,819	127,418	95%	120,994	6,424	127,536	95%	120,994	6,542
Coal	55,271	3,937	51,333	50,734	8%	3,937	46,796	49,681	8%	3,937	45,743
Large Hydro	33,396	20,830	12,566	30,654	68%	20,830	9,825	30,683	68%	20,830	9,853
Nuclear	43,825	32,158	11,668	40,228	80%	32,158	8,070	40,265	80%	32,158	8,108
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Biomass/ Wood	7,480	6,709	771	11,252	90%	10,127	1,125	7,480	90%	6,732	748
Geothermal	13,662	12,907	755	24,843	95%	23,477	1,366	13,662	95%	12,911	751
Solar PV	702	702	-	6,956	100%	6,956	-	56,777	100%	56,777	-
Solar Thermal	1,446	1,403	43	16,592	97%	16,095	498	1,446	97%	1,402	43
Small Hydro	4,416	3,729	687	4,461	84%	3,747	714	4,416	84%	3,709	707
Wind	11,794	9,209	2,585	31,812	78%	24,813	6,999	11,794	78%	9,199	2,595
Tot RPS	39,499	34,659	4,841	95,917		85,215	10,702	95,574		90,730	4,844

Table 3. High Load demand scenario for 33% RPS ideal reference and FIT 33% case.

				ARB 4/5/10 - Realistic 33% RPS lo-load scenario				FIT 33% hi load scenario			
	2009 est GWh	2009 In State GWh	2009 Imported GWh	GWh	% In state	In State GWh	Imported GWh	GWh	% In state	In State GWh	Imported GWh
N. Gas	138,813	120,994	17,819	142,818	85%	120,994	21,824	127,536	95%	120,994	6,542
Coal	55,271	3,937	51,333	50,734	8%	3,937	46,796	50,534	8%	3,937	46,596
Large Hydro	33,396	20,830	12,566	30,654	68%	20,830	9,825	30,683	68%	20,830	9,853
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RPS Eligible											
Biomass/ Wood	7,480	6,709	771	9,247	90%	8,322	925	7,480	90%	6,732	748
Geothermal	13,662	12,907	755	20,416	95%	19,293	1,123	13,662	95%	12,911	751
Solar PV	702	702	-	5,716	95%	5,430	286	55,938	99%	55,379	559
Solar Thermal	1,446	1,403	43	13,635	90%	12,272	1,364	1,446	90%	1,301	145
Small Hydro	4,416	3,729	687	4,417	84%	3,710	707	4,416	84%	3,709	707
Wind	11,794	9,209	2,585	26,143	60%	15,686	10,457	11,794	60%	7,076	4,718
Tot RPS	39,499	34,659	4,841	79,574		64,713	14,861	94,735		87,108	7,627

Table 4. High Load demand scenario for 33% RPS ideal reference and FIT 33% case.

Employment

For each scenario, the annual production supplied by each source is projected and employment in job-years associated from each source for each year is calculated based on a recent clean energy employment study from the University of California (http://rael.berkeley.edu/greenjobs). Employment multipliers include two types of direct jobs: "deployment" jobs in construction, installation and manufacturing, and "ongoing" jobs in operations, maintenance, and fuel purchase if applicable. Summing up all job-years over the ten-year period yields the total number of job-years for each scenario. The FIT case is then compared to the reference 33% case.

The overall employment number is taken as the average of the two cases (low load and high load). The solar PV based FIT scenario employment benefits from three key factors: (1) high employment multiplier per GWh electricity produced; (2) sharply decreasing FIT rates reflecting rapid technological progress and industry learning; and (3) more in-state jobs since virtually all solar PV is deployed in state.

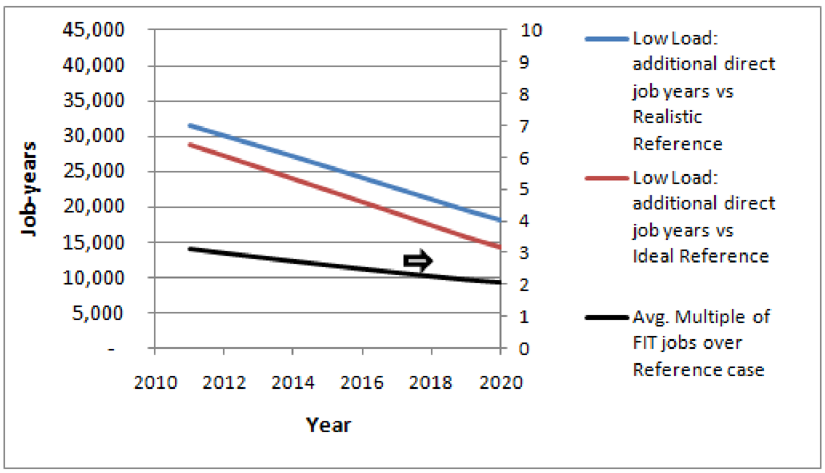
The approach for employment calculations is as follows: for each scenario, calculate GWh production supplied by each source and then calculate job-years associated from each source for each year based on updated Construction, Installation, and Manufacturing (CIM), and Operations and Maintenance (O&M) multipliers from Wei 2010 (multipliers given in units of job-years per year per GWh annual production).

Supply data is used from Tables 1-4 to project supply sources production by year. Domestic production of power for a given source is assumed to be non-decreasing from 2010 to 2020. In low load scenarios, reduction in overall power usage is taken from coal based imported power and domestic production is held constant. In high load scenarios with increases in power supply, supply amounts from a particular source are taken to increase linearly over time for simplicity.

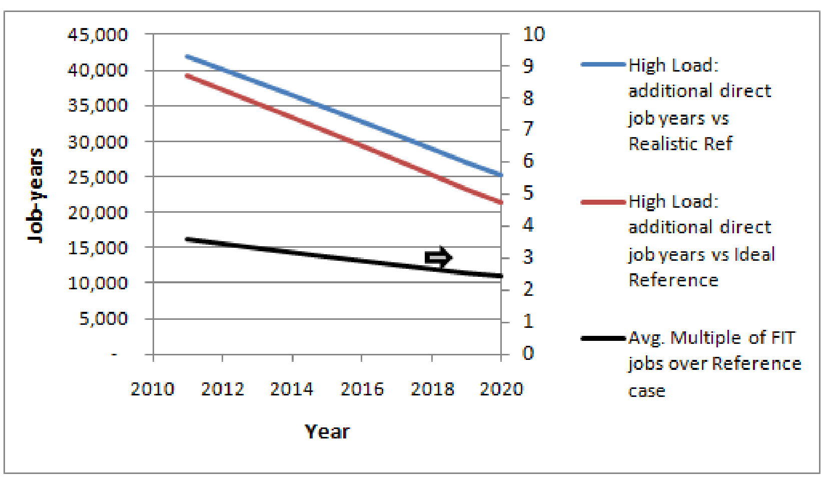
Employment multipliers are used from Wei 2010 to estimate employment associated with 33% reference scenario and 33% FIT scenario. The Wei 2010 model was modified from a U.S. national model to a California model. In particular, the multiplier for CIM was disaggregated to include: (1) the manufacturing fraction of CIM (see EIA 2010), and (2) the fraction of manufacturing that is done in California (Table 5). Second, the employment multiplier for solar PV has been adjusted to reflect data from Navigant 2007 and NREL-JEDI 2010 studies and the fact that lower multipliers are expected for larger scale construction projects (1-20 MW range for distributed generation) versus smaller installations assumed in Wei 2010. Finally, employment multipliers are assumed to decrease over time with industry learning occurs and economies of scale.

Work-hrs per year					Employment Components			Average Employment Over Life of Facility						
								Total jobs/MWp		Total jobs/MWa		Total person-yrs/GWh		
Energy Technology	Capacity Factor	Equipment lifetime (years)	CIM Manuf fraction	CA fraction manuf	Adj CIM (person-years/ MWp)	O&M (jobs/ MWp)	Fuel extraction & processing (person-yrs/GWh)	CIM	O&M and fuel process-ing	CIM	O&M and fuel proces s-ing	CIM	O&M and fuel process-ing	Total
BIOMASS	85%	40	50%	30%	4.16	0.89	0.07	0.10	1.37	0.12	1.61	0.014	0.18	0.20
GEOTHERMAL	90%	40	50%	30%	6.05	1.72	0.00	0.15	1.72	0.17	1.91	0.019	0.218	0.237
LANDFILL GAS	85%	40	50%	35%	8.44	0.24	0.13	0.21	1.21	0.25	1.42	0.028	0.162	0.191
SMALL HYDRO	55%	40	50%	30%	3.71	1.14	0.00	0.09	1.14	0.17	2.07	0.019	0.237	0.256
SOLAR PV	24%	25	30%	25%	19.76	0.17	0.00	0.79	0.17	3.29	0.71	0.376	0.081	0.457
SOLAR THERMAL	28%	25	50%	50%	5.13	0.53	0.00	0.21	0.53	0.73	1.90	0.084	0.217	0.301
WIND	35%	25	75%	15%	2.53	0.24	0.00	0.10	0.24	0.29	0.69	0.033	0.079	0.112

Table 5. Direct job multipliers for construction, installation, and manufacturing (CIM) and operations and maintenance (O&M), based on Wei 2010. All construction and installation jobs are assumed to be in-state.

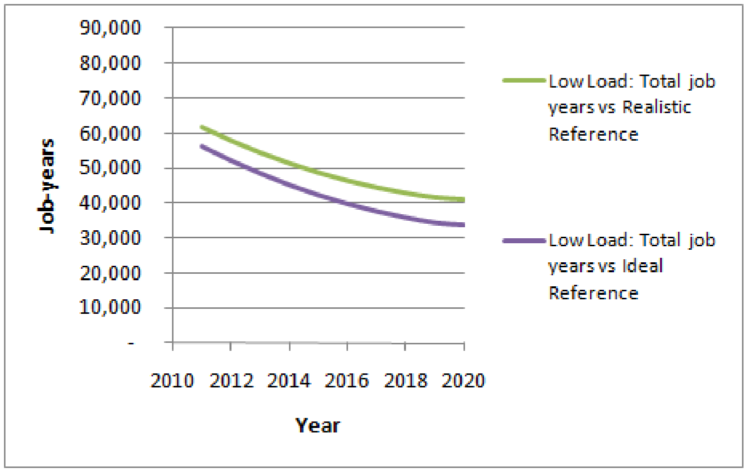


(a)

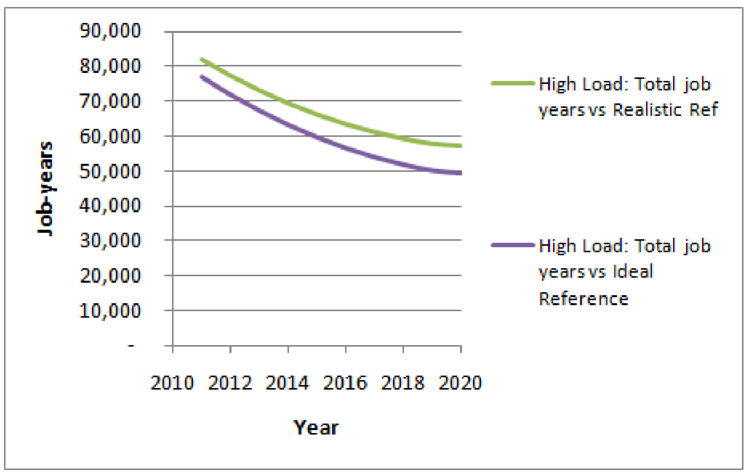


(b)

Figure 3(a) and 3(b). Additional direct job years per year for (a) Low Load and (b) High Load demand scenarios.



(a)



(b)

Figure 4(a) and 4(b). Additional total job years per year for (a) Low Load and (b) High Load demand scenarios. This includes direct jobs above and estimates of indirect and induced jobs.

Shown in the Figures 3(a) and 3(b) above are the additional direct (gross) number of jobs from CIM and O&M expected for the FIT scenarios. Additional direct job-years are seen to vary from an estimated 22,000 - 25,000 per year on average for the low load case to 30,000 - 34,000 per year on average for the high load case. This represents an average of 2-3 times more jobs per year than the reference case for the low load case and 2.5 to 3.5 times more jobs per year than the reference case for the high load case. The total average additional employment is about 28,000 jobs per year.

Induced and indirect jobs are taken as a unity multiplier of direct jobs based on job estimates from a number of references. For example, the Center for American Progress estimates 13.7 total job-years per one million invested in solar PV or about 1.5 indirect and induced jobs per direct job, while other studies have a lower multiplier e.g. NREL JEDI PV model has about 0.54 indirect and induced jobs per direct job. Indirect jobs associated with "supply chain" employment will depend on where supply parts are manufactured i.e. are they produced in state or imported from out of state.

Employment estimates are generally provided as *gross* number of jobs, for example the number of jobs associated with a certain level of investment. The *net* impact to employment should take into account the overall changes to sector level demand incurred by one investment path versus an alternative one. For example, increases in output from one form of renewable energy can occur at the expense of a another supply source such as coal or natural gas, and job generation in the former can be mitigated by job loss in the latter. Such an accounting requires a more detailed economic model that is beyond the scope of this work.

From our bottom up model we can make two adjustments that bring us closer to estimating net job impacts: job losses in the fossil fuel industry and induced job losses due to the impact of higher electricity rates. To first order, we do not project losses in the traditional energy sectors (natural gas, coal, large hydro and nuclear industries) since we model any reductions in these supply sources to come from a reduced volume of imports.

Tables 6 and 7 provide an illustration of induced job impacts from higher electricity rates. Here the annual net cost of an aggressive PV implementation is compared to the avoided costs of a reference combined cycle gas turbine (CCGT) plant, the base technology for market price referent (MPR) calculations by the CPUC. Annual net costs are translated to loss in consumer disposable income since we assume annual net costs translate directly into electricity rates. We assume that every million dollars loss in disposable income translates to a loss of 8.7 job-years (Pollin 2009). In the low load case, there are about 4,900 fewer induced jobs in the ten-year period; for the high load case, there are about 6,400 fewer induced jobs. Costs are taken after federal incentives. (Federal Production Tax Credit (PTC) and Investment Tax Credit (ITC) are assumed to continue at current level beyond their expiration dates in 2013 and 2016, respectively).

Alternatively, we can model the incremental costs to ratepayers of an aggressive solar PV build out versus the reference RPS build out that relies more on geothermal, solar thermal and wind. In this case we consider the incremental cost of solar PV compared to the CCGT avoided cost of solar versus the incremental cost of an RPS portfolio compared to its CCGT avoided costs. Induced job losses are lower here versus the CCGT avoided cost comparison primarily because of the relatively high price of solar thermal. In the realistic RPS reference scenarios since more energy is imported and more is paid in the form of unbundled REC charges, there is a small gain in induced jobs for the FIT case.

Since the indirect and induced employment is the least well defined of our job estimates and since the difference in total jobs in any FIT versus reference scenario is less than 10%, we take the first approach's lower set of estimates for total additional jobs. Including indirect and induced jobs and including the induced job loss, we arrive at the following employment numbers: 42,000-49,000 total additional job-years per year on average for the FIT case in the low load case, and 60,000-67,000 total additional job-years per year on average for the FIT case in the high load case (Figures 4(a) and 4(b) above).

Year	Low Load Energy (GWh)	FIT Rate ($/kWh)	Cumulative Limit	Quantity (GWh)	FIT Fulfillment of RPS	FIT Cost ($mil)	Avoided Cost ($/kWh)	Avoided Cost ($mil)	Annual Net Cost ($mil)	Annual job-yrs 8.7 job-yr/1million
2011	274,060	0.160	2.0%	4,982	2%	685	0.124	531	154	(1,341)
2012	272,971	0.152	4.0%	9,262	3%	1,335	0.128	1,077	258	(2,245)
2013	271,455	0.144	6.0%	13,541	5%	1,953	0.132	1,640	313	(2,724)
2014	269,518	0.137	8.0%	17,821	7%	2,540	0.135	2,220	320	(2,787)
2015	267,167	0.130	10.0%	22,101	8%	3,098	0.140	2,817	281	(2,443)
2016	264,410	0.124	12.0%	26,381	10%	3,628	0.144	3,433	195	(1,701)
2017	261,257	0.118	14.0%	30,661	12%	4,131	0.148	4,066	65	(567)
2018	257,720	0.112	16.0%	34,940	14%	4,610	0.152	4,719	(109)	950
2019	253,811	0.106	18.0%	39,220	15%	5,064	0.157	5,391	(327)	2,846
2020	249,439	0.101	20.0%	43,500	17%	5,495	0.162	6,083	(588)	5,115
sum										**(4,895)**

Table 6. FIT schedule for low load case. Total California electric load eligible for RPS decreases from approximately 275,000 GWh to 250,000GWh from 2010 to 2020 because of greater CHP and more energy efficiency. Last column of table represents the component of employment in the FIT scenario stemming from annual net cost of the program.

Year	High Load Energy (GWh)	FIT Rate ($/kWh)	Cumulative Limit	Quantity (GWh)	FIT Fulfillment of RPS	FIT Cost ($mil)	Avoided Cost ($/kWh)	Avoided Cost ($mil)	Annual Net Cost ($mil)	Annual job-yrs 8.7 job-yr/1million
2011	277,349	0.160	2.0%	6,310	2%	897	0.124	695	202	(1,757)
2012	279,686	0.152	4.0%	11,917	4%	1,750	0.128	1,411	338	(2,942)
2013	281,790	0.144	6.0%	17,525	6%	2,559	0.132	2,149	410	(3,569)
2014	283,656	0.137	8.0%	23,132	8%	3,329	0.135	2,909	420	(3,651)
2015	285,283	0.130	10.0%	28,740	10%	4,059	0.140	3,691	368	(3,201)
2016	286,665	0.124	12.0%	34,347	12%	4,754	0.144	4,497	256	(2,228)
2017	287,802	0.118	14.0%	39,955	14%	5,413	0.148	5,328	85	(743)
2018	288,689	0.112	16.0%	45,562	16%	6,040	0.152	6,183	(143)	1,245
2019	289,327	0.106	18.0%	51,170	18%	6,635	0.157	7,063	(429)	3,729
2020	289,713	0.101	20.0%	56,777	20%	7,200	0.162	7,971	(770)	6,702
sum										**(6,414)**

Table 7. FIT schedule for high load case. Total California electric load eligible for RPS increases from approximately 275,000 GWh to 290,000GWh from 2010 to 2020. Last column of table represents the component of employment in the FIT scenario stemming from annual net cost of the program.

Cost Discussion

For Solar PV the avoided cost is taken as 1.23 times the MPR based on the average Time of Day correction for four representative locations across the state (CAL SEIA 2010). Solar PV benefits due to the fact that in general its peak production output occurs in a similar time frame as peak demand (e.g. hot summer afternoons). Wind on the other hand has an avoided cost 1-2 cents/kWh below MPR due to its generally “out of phase” delivery of power at night during periods of low demand. The avoided cost for Biomass, Geothermal assumed to be same as MPR based costs. REC values are taken at $0.035/kWH or the average of high and low estimates of $50/MWh to $20/MWh (CAL SEIA 2010). The MPR includes provisions for a gradually increasing carbon price, escalation in costs for capital investment and O&M as well as hedging for fuel price increases.

The FIT rate for solar is based on several sources: NREL solar selector model (NREL 2010), market data points, and SMUD FIT rates. We start at a FIT rate of $.16kWh and installed cost of $3800/kWp in 2011 and decrement by the FIT rate by 5% a year. Inverter costs (replacement required every 8-10 years) are subsumed into the FIT rate. As a point of reference, SMUD recently instituted a FIT program at $.137/kWh and the program has been fully subscribed.

Transmission and distribution is not explicitly included but is expected to be a key benefit for FIT supported distributed generation because faster implementation of distributed generation versus centralized power plants is possible by avoiding the cost and delays associated with new transmission lines. The required transmission to support a CARB reference-like 33% RPS in 2020 is not fully known with estimates up to $12 billion (CPUC 2009).

A more in-depth study of transmission requirements and the employment impact of significant new transmission investment and construction is beyond the scope of this work.

Note also that any distribution system upgrades associated with the FIT are by state law required to be covered by developers and therefore there are no hidden "pass-through" transmission and distribution charges that would affect ratepayers under the FIT program beyond the FIT rates in Tables 6 and 7.

Energy storage is not included in our analysis and could become critically important for system robustness and load balancing as larger volumes of non-dispatchable supply sources such as wind, solar, and non-storage equipped solar thermal plants become operational. For example, a large installed base of solar PV may have issues associated with the ramping down of large quantities of peak power on short time scales while system-wide demand is still high. Certainly better energy management practices such as higher penetration levels of automated demand response and improved infrastructure such as the "smart grid" will mitigate these issues.

Revenues to State

A total of $1.7 billion in additional tax revenue is expected over the ten-year period from additional sales tax, use tax, and income tax on an undiscounted basis in 2009 constant dollars. This is the average of the additional revenue expected from the low load and the high load cases above versus a 33% RPS reference case. This revenue is derived by disaggregating the installed cost for each technology into materials, labor and other (e.g. design, permitting, profit). All construction and installation costs are assumed to be in-state. Sales tax from the cost of materials accounts for the bulk of this revenue. For equipment that is produced outside the state, we assume that a use tax is levied at the same rate as the sales tax. Investors will also benefit from the federal investment tax credit that currently runs through 2016 and is assumed to continue through 2020. We note that revenue figures are also "gross" revenues in that they do not fully capture effects of potentially lost revenues from other sectors that may be affected in pursuing one investment path versus an alternative path.

Induced revenue is based upon additional employee compensation in the FIT case leading to more consumption and therefore more sales tax. It is calculated on an annual basis by considering additional employee compensation and subtracting the net FIT rate impact. Every $1 increase in employee compensation is assumed to result in $.82 in household consumption due to subsequent spending and re-circulation through the economy

(Pollin 2009). Induced revenue from this effect is calculated to be about $600 million on average. Revenue calculation does not include corporate income taxes or induced revenues from state income taxes

Revenue Calculation

Solar PV has both a higher capital cost per peak kW and a lower capacity factor than other renewable energy sources. Thus to generate the same amount of annual energy as other renewable energy sources, much higher investment amounts are required in the first few years of the decade. Higher revenues to the state in the form of sales tax and income tax are expected from the larger investment required for solar PV supplied electricity.

We consider revenue from sales tax, property tax, and income tax. Our approach is to disaggregate the installed cost for each technology into materials, labor and other as in Table 8. All construction and installation costs are assumed to be in-state. ("Other" includes design, engineering, permitting, site-related costs, and profit).

We assume the installed costs in Table 9, the tax rates in Table 10, and do not include financing costs for the duration of plant construction. For example, a state income tax rate of 2.2% is based on the average effective tax rate for single and married filers making an average salary of $46,000 per year for a construction worker. For equipment that is produced outside the state, we assume that a use tax is levied at the same rate as the sales tax.

A summary of annual revenue to the state is shown in Tables 11 and 12. Most of the revenue is from sales or use taxes and the annual revenue trends down over time due to the rapidly falling installed cost trend for solar PV.

RPS Supply Source	Materials	Labor	Other	Ref
Biomass	64%	14%	23%	Author estimate
Geothrm	60%	20%	20%	Geotherm Association 2006
Solar PV	60%	11%	29%	NREL08, JEDI PV model
Solar Thermal	67%	17%	16%	NREL06, JEDI CSP model
Small Hydro	64%	14%	23%	Author estimate
Wind	90%	7%	3%	JEDI wind model

Table 8. Estimated breakdown of materials, labor and other components of capital costs for various RPS supply sources.

Installed Cost [Real 2009$/kW]	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Biomass/ Wood	$ 2,900	$ 2,900	$ 2,900	$ 2,900	$ 2,900	$ 2,900	$ 2,900	$ 2,900	$ 2,900	$ 2,900	$ 2,900
Geothermal	$ 3,800	$ 3,795	$ 3,790	$ 3,785	$ 3,780	$ 3,775	$ 3,770	$ 3,765	$ 3,760	$ 3,755	$ 3,750
Solar PV	$ 4,000	$ 3,805	$ 3,610	$ 3,415	$ 3,220	$ 3,025	$ 2,830	$ 2,635	$ 2,440	$ 2,245	$ 2,050
Solar Thermal	$ 3,300	$ 3,210	$ 3,120	$ 3,030	$ 2,940	$ 2,850	$ 2,760	$ 2,670	$ 2,580	$ 2,490	$ 2,400
Small Hydro	$ 1,700	$ 1,700	$ 1,700	$ 1,700	$ 1,700	$ 1,700	$ 1,700	$ 1,700	$ 1,700	$ 1,700	$ 1,700
Wind	$ 1,950	$ 1,925	$ 1,900	$ 1,875	$ 1,850	$ 1,825	$ 1,800	$ 1,775	$ 1,750	$ 1,725	$ 1,700

Table 9. Installed cost of renewable energy supply sources (from CEC 2009, NREL, and market estimates).

Sales tax	8.5%
Income tax, state	2.2%
Property Tax rate	1.1%
Annual cost of material inc.	2.5%
Annual depreciation	10.0%

Table 10. Tax rate assumptions for revenue calculation.

FIT vs Ideal RPS Reference	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	Total
Total state revenue, Low Load reference	$ 185	$ 178	$ 171	$ 165	$ 159	$ 152	$ 146	$ 139	$ 133	$ 127	
Total state revenue, Low Load FIT scenario	$ 414	$ 393	$ 371	$ 350	$ 329	$ 308	$ 287	$ 265	$ 244	$ 223	
Low Load 33% FIT additional revenue	$ 175	$ 161	$ 146	$ 132	$ 118	$ 103	$ 89	$ 75	$ 60	$ 45	$1,104
Induced revenue estimate	$ 57	$ 51	$ 46	$ 42	$ 40	$ 38	$ 38	$ 39	$ 41	$ 44	$ 434
Total state revenue, High Load reference	$ 231	$ 223	$ 215	$ 208	$ 200	$ 193	$ 185	$ 178	$ 170	$ 163	
Total state revenue, High Load FIT scenario	$ 542	$ 514	$ 487	$ 459	$ 431	$ 403	$ 375	$ 348	$ 320	$ 292	
High Load 33% FIT additional revenue	$ 235	$ 216	$ 197	$ 178	$ 158	$ 139	$ 119	$ 100	$ 80	$ 61	$1,483
Induced revenue estimate	$ 77	$ 69	$ 63	$ 59	$ 56	$ 54	$ 54	$ 56	$ 58	$ 63	$ 610

Table 11. Additional state revenue projections (undiscounted) from sales tax, use tax, and income tax for 33% FIT scenarios vs ideal RPS reference [2009 million $].

FIT vs Realistic RPS Reference	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	
Total state revenue, Low Load reference	$ 185	$ 178	$ 171	$ 165	$ 159	$ 152	$ 146	$ 139	$ 133	$ 127	
Total state revenue, Low Load FIT scenario	$ 410	$ 389	$ 368	$ 347	$ 326	$ 305	$ 284	$ 263	$ 242	$ 221	
Low Load 33% FIT additional revenue	$ 258	$ 242	$ 227	$ 211	$ 196	$ 180	$ 164	$ 149	$ 133	$ 117	$1,876
Induced revenue estimate	$ 62	$ 57	$ 53	$ 50	$ 49	$ 49	$ 49	$ 51	$ 54	$ 59	$ 534
Total state revenue, High Load reference	$ 231	$ 223	$ 215	$ 208	$ 200	$ 193	$ 185	$ 178	$ 170	$ 163	
Total state revenue, High Load FIT scenario	$ 534	$ 507	$ 479	$ 452	$ 425	$ 397	$ 370	$ 342	$ 315	$ 288	
High Load 33% FIT additional revenue	$ 341	$ 320	$ 298	$ 276	$ 255	$ 233	$ 211	$ 190	$ 168	$ 146	$2,438
Induced revenue estimate	$ 83	$ 76	$ 71	$ 68	$ 66	$ 65	$ 66	$ 69	$ 72	$ 78	$ 714

Table 12. Additional state revenue projections (undiscounted) from sales tax, use tax, and income tax for 33% FIT scenarios vs realistic RPS reference [2009 million $].

Total investment for FIT vs reference cases is shown in Figure 5 using the installed costs in Table 9 and the high and low load electricity demand scenarios described above. The FIT program would result in up to $50 billion additional investment over the next decade. Assuming a 30% investment tax credit throughout the investment period, developers would be eligible for up to $15 billion in federal tax credits. On average, an increase in investment of about $38 billion is projected with the FIT over the reference 33% RPS scenarios.

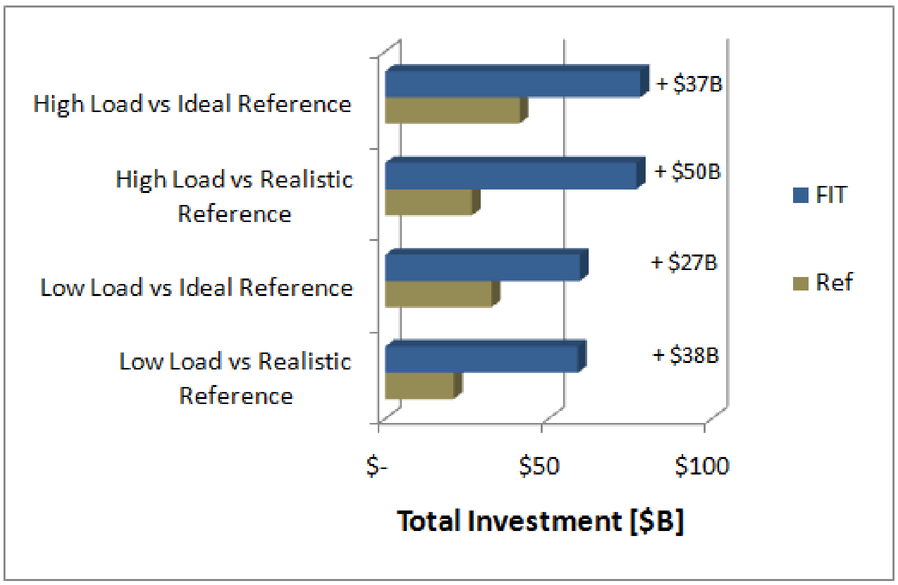


Figure 5. Total investment for FIT vs reference cases (undiscounted 2009 $) from 2011-2020.

Conclusions

The REESA FIT can drive a massive volume of cost-effective renewable energy in the near-term. With virtually 100% of the deployments in-state, the program will result in significant employment and tax revenue benefits to California, stimulate activity in the renewable energy industries, increase the ability to get federal dollars into California, and provide money to local economies and to employ workers in sustainable jobs.

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