Repowering America: Creating Jobs

October, 2011

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Executive Summary

- The DBCCA Electric Power Forecast for the U.S. calls for a scale up in natural gas and renewable energy (RE) as coal plants are retired and energy efficiency (EE) reduces the rate of growth in electricity demand over the next 20 years. (Detailed analysis of the DBCCA Electric Power Forecast is included in the companion white paper: *Natural Gas and Renewables: The Coal to Gas and Renewables Switch is on!*) Based on this, we have estimated job forecasts using and expanding a modeling methodology developed at the University of California, Berkeley (henceforth referred to as "WPK"), that was selected after a detailed review of leading U.S. research reports looking at job creation and energy related investments or initiatives. Our modeling results focus on direct jobs and indirect through the supply chain. They incorporate the expected leakage of manufacturing demand into imports, net out job losses in coal and nuclear, while including the expected increase in pipeline and transmission related infrastructure that will be required. They do not attempt to adjust for either induced spending that comes from energy efficiency savings nor potential reductions in spending due to the cost of implementing the power supply mix switch. They also assume a phasing out of oil for electricity generation, a modest introduction of coal CCS, and retirement of existing older coal plants as new cleaner gas power plants are commissioned. The results are based on the use of proven technologies for all new power supply investment

- Over the period 2010-2030, we expect around **7.9 million cumulative net job-years** of direct and indirect employment (see table below) to be created as a result of this electricity supply forecast outlook. Around 64% of these jobs would be related to the construction, installation and manufacturing (CIM) phase of these new investments, the balance associated with the operations, maintenance, fuel processing (O&M) phase and energy efficiency (EE) related initiatives.

- As a result, by 2020 and extending out to 2030, there are **around 500,000 net new jobs** in place compared with the start, 2010. Once the large CIM phase is over, what remains are permanent jobs related to the operations, maintenance and fuel processing (O&M) of the new power supply sources, the newly installed gas and power lines infrastructure, and related the indirect jobs these create in the supply chain. These total about 40% of the 486,000 net new jobs in 2030. As expected, the ongoing job creation impact of O&M is much less than the jobs created in the CIM phase, but this increase in permanent job creation is meaningful.

— There is not yet a universally accepted standard of how to report job growth estimates associated with cleaner energy investments. When cumulative job-years figures are reported this gives the largest jobs growth estimate over a forecast period – which is much different than looking at the increase in new full-time jobs in place in a particular year, such as at the end of the forecast period. In terms of our own research, it is possible to simultaneously report "7.9 million cumulative job-years created" or "486,000 jobs created". The difference is that the "7.9 million job-years" figure is the cumulative total of **all jobs** (defined as full-time employment for 1 year) created over the 20 year forecast period, while the latter "486,000 jobs" figure is an end point or final year estimate of new full-time employment in place vs. the starting point of the forecast[1]. Both jobs outcomes are important and certainly in terms of an economic stimulus, the CIM phase provides a sizeable impact over the forecast period, which is what the U.S. economy needs right now.

— The job creation multipliers for solar and wind were adjusted so as to reflect the high import content of many of the manufacturing components used. In the case of solar, we have assumed around 60% of the manufactured components are imported and for wind around 40% (based on industry analysis estimates). However, it is important to note that the majority of the installation work of the components and structures and ongoing O&M work created cannot be exported and remains onshore.

— Our forecasts also capture the job creation impact of constructing the new gas pipelines and power transmission lines that will be needed as a result of our energy supply outlook through to 2030. We expect that around 30,000 miles of new power transmission lines will need to be built and a 10-12% expansion in the current gas pipeline infrastructure.

— After deriving aggregate jobs growth forecasts for RE, new gas power, and EE related initiatives, the next step of drilling down to an occupational breakdown is a more involved exercise and requires a number of assumptions about the occupational make-up of the RE, EE, gas and coal power supply sectors. The reason for this is that the current labor market data supplied by the U.S. Bureau of Labor Statistics (BLS) does not provide explicit occupational data on the RE, EE, gas and coal power supply sectors. As a result, like other researchers, to do this step we have used a number of surveys and research on occupations in the cleaner energy sectors to construct our own hybrid breakdowns for the occupational make-up of the RE, EE, gas and coal power supply sectors and applied these to the current BLS occupational data. In 2012, this task will become somewhat easier to do once the BLS publishes its own new survey reports on the green economy, which will include details on many of the RE sectors that we have looked at in this report.

— Looking at the occupational breakdown in terms of numbers, we see that manufacturing and production is the largest sector for growth even after import leakage, with construction and installation along with maintenance then the next most significant. These are mostly skilled occupations. Supporting sectors like engineering, technical services and indeed administrative jobs all feature as well.

— In terms of occupations that are truly new, unique and specifically the result of new investments in RE and EE initiatives, in reality there are few of these. Investments related to the cleaner energy economy largely create new demand for workers across a wide range of existing occupations, few of which are truly unique and specific to the cleaner energy economy. There are some new skills in demand, like for a wind turbine technician, solar PV installer, or energy auditor, but the rest of the work required to design, build and operate a RE power system, build a new gas power plant, create more EE appliances and buildings, build new gas pipelines and power transmission lines, can all be done using the current workforce and their existing skill sets. .. With the U.S. economy needing increased job creation now, these new cleaner energy related investments hold the potential for creating new jobs immediately and do not require large numbers of people to be re-trained or re-skilled to do this work. The majority of the work can be done by people who already have the required skills and training.

— The truly complex area of estimating the total economy wide impact on job creation from energy efficiency (EE) initiatives and changes to the power supply system comes in the area of "induced" jobs. Energy cost savings free up spending elsewhere in the economy, in turn creating even more jobs. Although the model

[1] In terms of the model, this is the number of job-years in that particular year. A job-year of employment is defined as full-time employment for one person during one year (measured by a standard 2,080 hrs of employment/year).

used does attempt to quantify this for EE (estimating around an additional 140,000 new jobs by 2030 – see Appendix), it does not attempt to quantify the full costs of the power switch over 20 years. Whilst the forecast gas to coal switch looks economically viable on many measures and renewable energy costs continue to fall, potential price movements in all types of fuel options are very uncertain; if the costs are high this would reduce spending elsewhere, offsetting the efficiency job gains the model may otherwise be forecasting. As a result, we have not included in our results either induced EE job creation or the potential cost of the power supply switch for end-users.

— Our paper is not a full Cost-Benefit analysis, which would require a full general equilibrium model that also included the environmental externality costs to be truly inclusive. A discussion of the advantages and drawbacks of this approach versus the more targeted type of analysis that we have done can be found in range of papers, in particular between the Heritage Foundation and PERI. [2] There is also a discussion around the topic of labor productivity. From our perspective we agree with many of the points made by PERI, namely, that a general equilibrium model has many challenges when tackling such a complex system. In particular, weighing up the future relative cost, as discussed above, is highly uncertain. The more direct approach we have taken of using a partial yet comprehensive model can identify specific job outcomes more transparently.

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- In summary our research indicates there will be strong job growth for a wide range of well-paid existing occupations, like construction, manufacturing, engineering, and related professional services and further shows:
    - RE and low carbon sources can generate more jobs per unit of delivered energy than traditional fossil-fuel based sources
    - Amongst the RE technologies, at this time solar PV creates the most jobs per unit of electricity output
    - Switching from coal to gas delivers more new ongoing gas jobs per GW added than those lost from removing one GW of coal powered capacity.
    - Energy efficiency measures can be economically the least costly way to create jobs, reducing the need for additional new energy supply sources (be they RE, traditional fossil fuel plants, or low carbon sources).

[2] See Heritage Foundation, 2009, "The PERI Report on Clean Energy: The Wrong Question and a Misleading Result"; PERI, 2009, "Clean Energy Investments, Jobs, and U.S. Economic Well-Being: A Third Response to Heritage Foundation Critics" for more detail.

Power Market Forecasts
DBCCA is also releasing a companion document updating our original thesis on the future path for power markets in the US – *Natural Gas and Renewables: The Coal to Gas and Renewables Switch is On!*.This study again looks at the feasibility of a gas and renewable switch for coal and the environmental effects of that, including gas supply from fracking.

Exhibit 1: DBCCA Energy Supply Forecasts

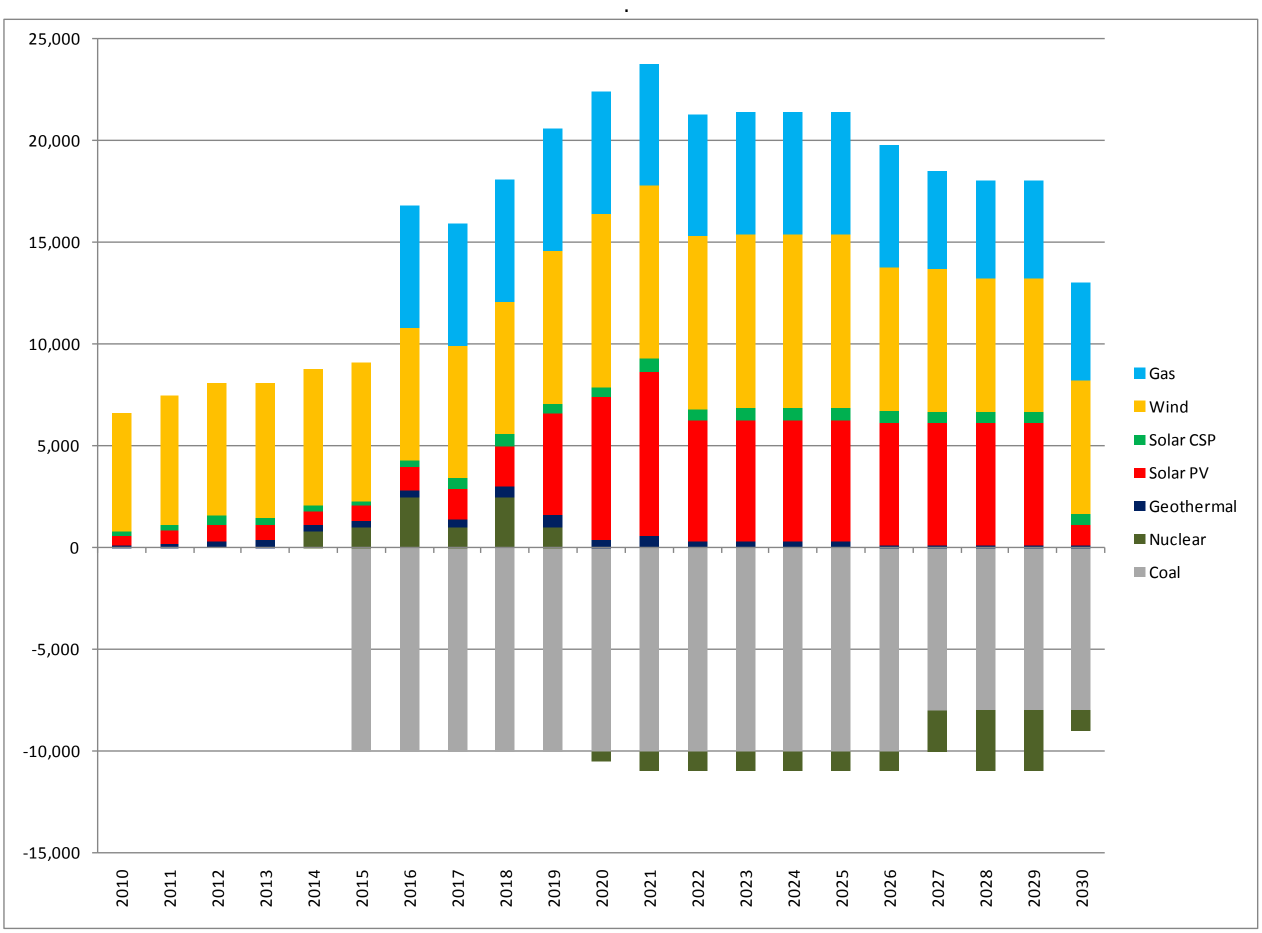
US Electricity Supply (% total TWh)	2005A	2010A	2020E	2030E	Comment
Coal traditional	50%	45%	32%	20%	Reduced to meet emissions target and comply with EPA regulation
Coal CCS	0%	0%	0%	1%	Limited deployment 2020-2030 with government R&D support
Natural gas	19%	24%	32%	38%	Coal to gas fuel switch, underutilized assets, strong new build
Natural gas CCS	0%	0%	0%	0%	No deployment, assume that gas CCS is viable post 2030 and cheaper $/MWh than coal
Petroleum	3%	1%	0%	0%	No additions; existing capital stock remains for reliability but hardly used
Nuclear	19%	19%	20%	17%	"Uprates" and new builds unable to keep up with retirements; Fukushima impact
Wind and solar (intermittent)	0%	3%	9%	17%	Large capacity additions to comply with RPS; improved cost competitiveness
Baseload renewables (geothermal & hydro)	7%	8%	7%	7%	Share decreases modestly as only very limited new builds
Total	**100%**	**100%**	**100%**	**100%**	
Renewables share total (intermittent and baseload)	9%	11%	16%	24%	Doubling of share 2010 to 2030 due to wind and solar additions to meet RPS
Electricity Demand (kWh)	4,055	3,784	3,978	4,322	0.7% CAGR growth due to energy efficiency and operational improvements
CO2 emissions (mn metric tons @ burner tip)	2,397	2,200	1,655	1,407	Emissions reduced substantially due to the coal to gas fuel switch and build-up in renewables
CO2 emissions (mn metric tons; full lifecycle)	3,026	2,654	2,342	2,096	Gas has relatively higher upstream GHGs than coal, which reduces full life-cycle impact of GHG reduction
% CO2 emissions reduction vs. 2005 @ burner tip		**-12%**	**-31%**	**-41%**	
% CO2 emissions reduction vs. 2005 @ full lifecycle (LCA)		**-12%**	**-23%**	**-31%**	

Source: EIA, DBCCA analysis 2011

The main features in this forecast are:

- Big shift from coal to gas as a source for electricity supply
- Big increase in supply from RE such as solar and wind
- Nuclear sidelined due to the Fukushima disaster
- **Energy efficiency is expected to increase, limiting the compound annual growth rate in electricity demand to 0.7% per annum**

Exhibit 2: DBCCA Energy Supply Forecasts - new capacity additions / removals by sector



Source: WPK Model, DBCCA Analysis.

Exhibit 3: Cumulative Job-Years of Employment, Total During 2010-2030

Cumulative change during 2010-2030	CIM direct	CIM indirect	O & M direct	O & M indirect	Total direct	Total indirect	Sum total	% share
Geothermal	56,323	50,690	135,200	121,680	191,523	172,371	363,894	5%
Solar PV	1,251,949	1,126,754	359,332	323,399	1,611,280	1,450,152	3,061,433	38%
Solar Thermal	25,639	23,075	30,493	27,444	56,131	50,518	106,650	1%
Wind	749,315	674,383	403,669	363,302	1,152,984	1,037,685	2,190,669	28%
Subtotal - RE	2,083,224	1,874,902	928,694	835,825	3,011,919	2,710,727	5,722,645	72%
Natural Gas	82,008	73,807	754,260	678,834	836,268	752,641	1,588,910	20%
Pipelines & Electricity Grid	363,000	326,700	43,052	38,747	406,052	365,447	771,499	10%
Coal , Oil, Coal CCS	40,960	36,864	(578,208)	(520,387)	(537,248)	(483,523)	(1,020,772)	-13%
Nuclear	107,008	96,307	32,911	29,620	139,919	125,927	265,847	3%
EE (Energy Efficiency)	342,806	291,007	NA	NA	342,806	291,007	633,814	8%
Total	3,019,007	2,699,588	1,180,710	1,062,639	4,199,716	3,762,226	7,961,943	100%

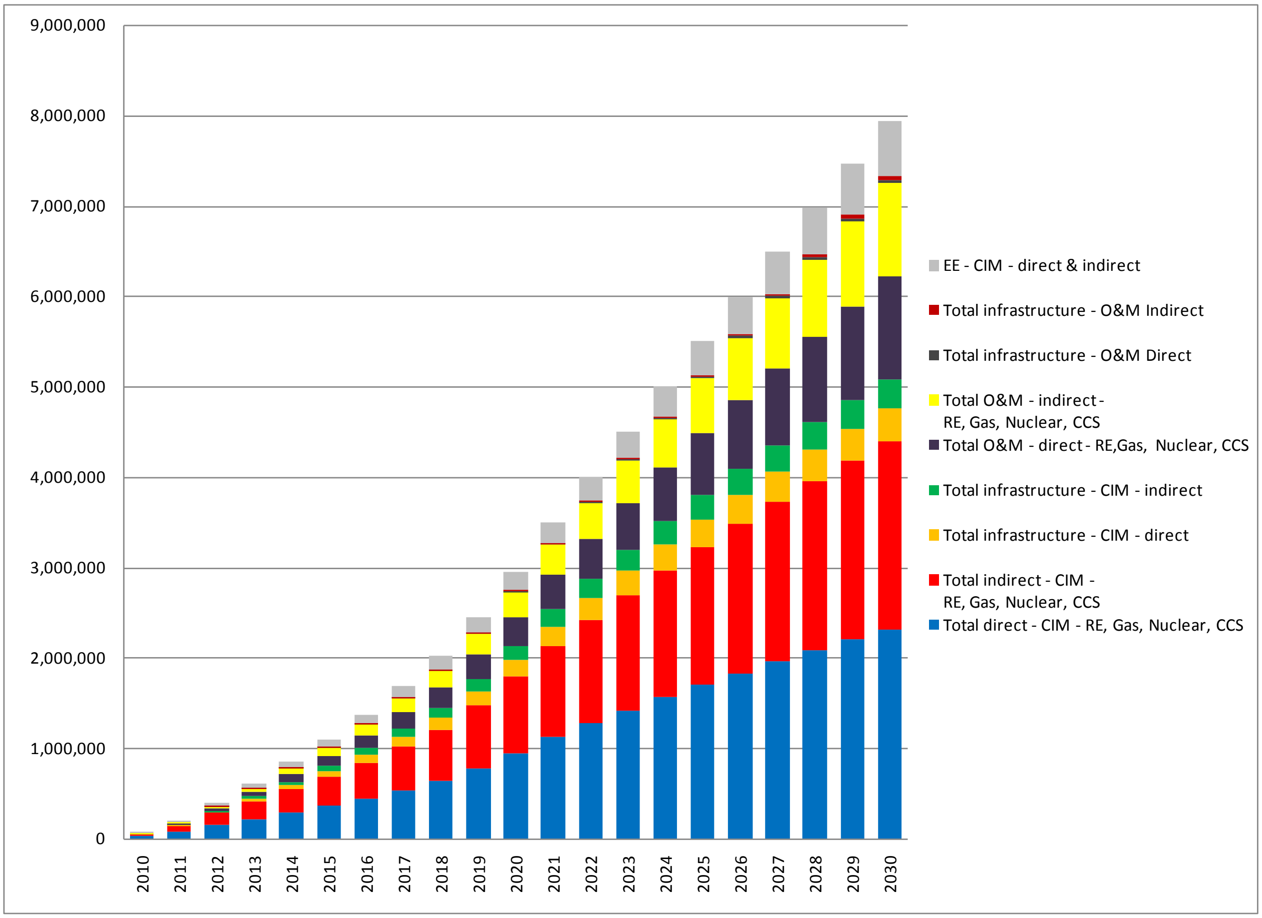
Notes:
Data refers to number of job-years: that is years of FTE (full-time equivalent) employment (2,080 hrs work, per job, per year).
The change in employment is using the DBCCA energy forecast during 2010-2030 (cumulative, adding each year's total employment)
CIM (direct): employment directly related to the construction, installation or manufacture
CIM (indirect): second-round effects which relate to suppliers who are doing the CIM
O&M (direct); direct operations and maintenance employment
O&M (indirect): second-round employment that relates to those who are doing the O&M work

Exhibit 4: Employment Gains in 2030 vs. end of 2009

Increase / (decrease) in jobs 2030 vs. 2009	CIM direct	CIM indirect	O & M direct	O & M indirect	Total direct	Total indirect	Sum total	% share
Geothermal	931	838	10,964	9,867	11,895	10,705	22,600	5%
Solar PV	76,945	69,251	43,814	39,433	120,759	108,683	229,443	47%
Solar Thermal	469	422	2,463	2,217	2,932	2,639	5,571	1%
Wind	33,144	29,830	38,410	34,569	71,555	64,399	135,954	28%
Subtotal - RE	111,489	100,340	95,651	86,086	207,141	186,427	393,567	81%
Natural Gas	4,896	4,406	68,664	61,797	73,560	66,204	139,764	29%
Pipelines & Electricity Grid	7,505	6,755	4,192	3,773	11,697	10,527	22,224	5%
Coal , Oil, Coal CCS	0	0	(62,374)	(56,136)	(62,374)	(56,136)	(118,510)	-24%
Nuclear	0	0	(3,039)	(2,735)	(3,039)	(2,735)	(5,774)	-1%
EE (Energy Efficiency)	28,679	25,640	NA	NA	28,679	25,640	54,319	11%
Total net	152,569	137,141	103,095	92,785	255,664	229,926	485,591	100%

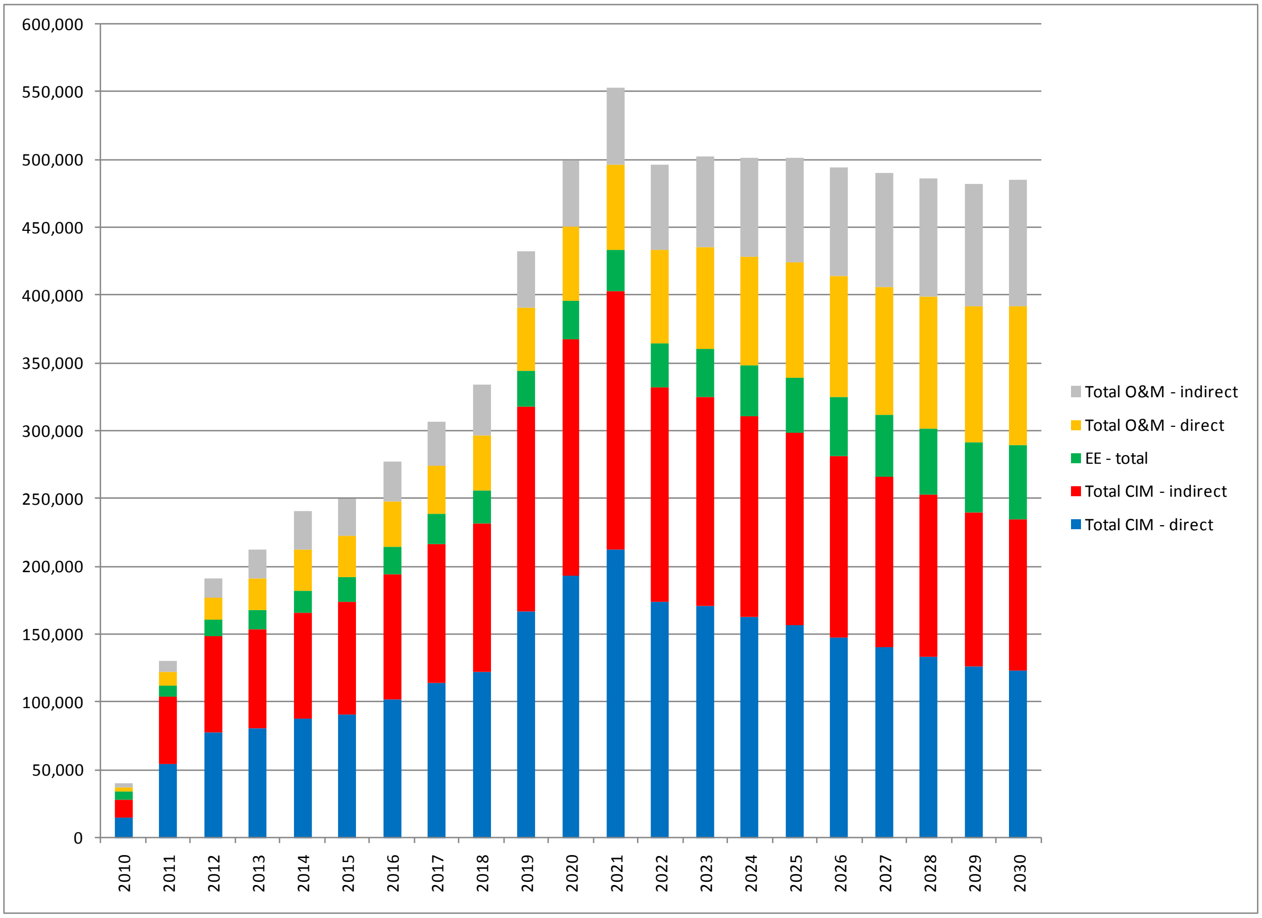
Notes:
Data refers to number of new jobs in place in 2030 vs. 2009.
A job is defined as one year of FTE (full-time equivalent) employment (2,080 hours per person, per year)
The change in employment is using the DBCCA energy forecast vs. 2009 start point
CIM (direct): employment directly related to the construction, installation or manufacture
CIM (indirect): second-round employment, that which relates to suppliers who are doing the CIM
O&M (direct); direct operations and maintenance employment
O&M (indirect): second-round employment that relates to those who are doing the O&M work

Exhibit 5: Cumulative Jobs Growth, 2010-2030



Source: WPK Model, DBCCA Analysis.

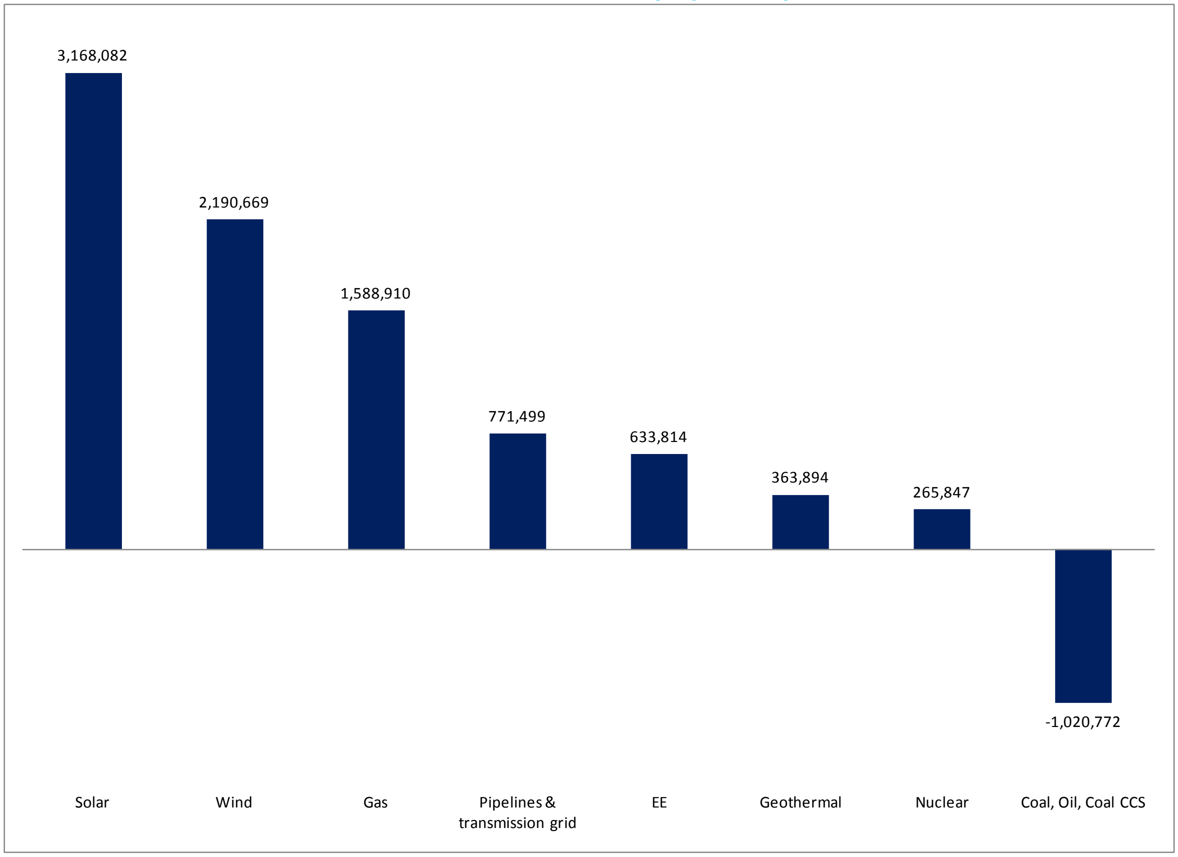
Exhibit 6: Annual Net Job Additions (by sector and type)



Source: WPK Model, DBCCA Analysis.

Looking at the forecasts (cumulative outcome) we see that the largest number of new jobs will be created as a result of solar, wind, gas, and EE. The coal supply sector is the biggest loser – not surprising because the DBCCA energy supply forecasts assume more than a halving in the share of power being supplied by coal (and with that comes a large retirement in existing coal power supply facilities). Of the forecast coal O&M job losses, around 30% are related to power plant operations, 46% with coal fuel supply (mining), and the balance with coal fuel transportation. The coal CIM jobs we show in the forecast are from the coal CCS additions we are assuming during 2015-2022. Although we forecast nuclear plant retirements from 2020 onwards, up till then our forecasts capture the expected completion of plants already expected to be commissioned by then. So we see CIM jobs from nuclear early on, followed by O&M job losses in the latter part of the forecast. We do not include any job estimates for decommissioning of existing coal and nuclear power plants.

Exhibit 7: Cumulative Job-Years of Full-Time Employment by Sector – 2010-2030

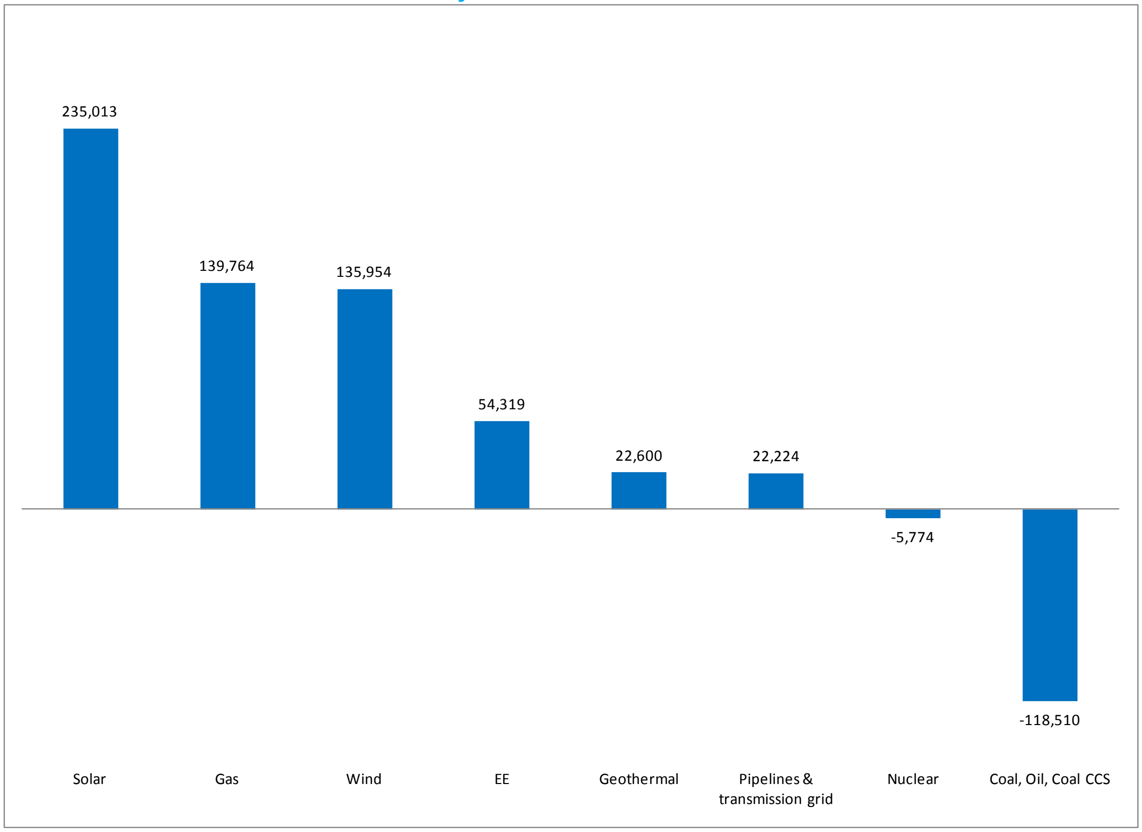


Source: WPK Model, DBCCA Analysis.

The cumulative 7.9 million increase in net job-years is an impressive outcome and is largely driven by CIM jobs required in the plant building phase. Almost 64% (5.1 million) of the job-years created are a result of the CIM that results from the new RE investments, the change from coal to gas fired power plants, and associated infrastructure pipeline and transmission line investments.

Looking at 2030, of the 486,000 new jobs in place in that year we find that around 54,000 are a result of EE initiatives; about 196,000 are newly created O&M jobs (this is a net figure, after allowing for losses in coal O&M jobs due to forecast coal plant retirements). The balance (i.e. 235,000) are CIM related jobs (direct and indirect) associated with the installation of the new energy systems and as a result will in time dissipate when the project construction phase is complete for these investments (e.g. those new plant installations that are initiated in the latter part of the 2010-2030 forecast period). This means that of the forecast 486,000 net new jobs in place by 2030 around 40% are O&M jobs (direct and indirect) associated with servicing the new power installations, around 11% related to EE initiatives, with the remainder (49%) related to the remaining CIM work. Our assumptions on the leakage of manufactured components into imports reduced this total 486,000 jobs figure by around 90,000.

Exhibit 8: Total Net New Jobs by Sector in 2030 vs. end of 2009 - Job-Years of Full-Time Employment



Source: WPK Model, DBCCA Analysis.

In moving away from coal and increasing the use of gas, we see how O&M jobs in coal will decline but those required for gas O&M will increase. The DBCCA forecasts are assuming -152,000 MW of coal plant retirements during 2016-2030 with +89,600 MW of gas fired capacity being added. We assume that the utilization of the existing gas capacity increases until 2016 after when the new gas plants will come on line so there is no need to build as much new gas capacity to replace the coal capacity being retired. We forecast some coal CIM jobs as result of some coal CCS capacity being installed. With this will also come coal CCS related O&M jobs, lessening somewhat the total net loss in coal O&M jobs during the forecast period. We have not estimated any jobs associated with decommission existing coal power plants.

On nuclear, we show around 107,000 job-years of direct CIM employment (cumulative) during the forecast period as currently planned installations are built and completed. Thereafter, we assume no new capacity is added and older plants start to be decommissioned. As a result, we show CIM jobs early on followed by net O&M job losses in the latter part of the forecast period. This shows up more in the end 2030 numbers. On power supply related infrastructure that are assumed in the DBCCA electricity supply outlook forecast, over 80% of the direct CIM jobs come from new power transmission line investments, the balance from new gas pipeline investments.

In terms of the occupational employment breakdown of these forecasts, we approached this by first deriving an occupational snapshot of jobs required for each sector (geothermal, solar, wind, gas, etc.). If this was not available from official statistics or from an industry survey, we used the best available research on the sector that allows one to create a hybrid occupational profile, typically relying on the BLS occupational statistics as the core components. That is, we looked at the industry inputs that are required in the CIM and O&M phase of each power supply sector, and assigned a weighting to each, resulting in a hybrid industry make-up. We then examined the BLS occupational job data associated with each industry that rolls up into these hybrid power sectors. This yielded estimates for direct CIM and O&M employment by occupation for each sector. To this we added the total indirect employment from all sectors.

The indirect employment occupational breakdowns were derived by taking the occupational breakdown of private sector employment in the economy and removing any occupation that is not likely to be involved (e.g. tertiary sectors like health care, education, entertainment etc.) as well as any occupations that may have already been covered in the CIM phase. Although some may argue this is not precise enough, in the absence of a very detailed input-output model and without detailed RE, gas and EE sector employment data, in our opinion it is the best way to approach this issue. We discuss our methodology in more detail later. The table below illustrates the aggregate occupational breakdown implied by our forecasts. We note that this type of analysis does come with a number of provisos as our model assumes a fixed set of employment multipliers over a 20 year period, during which technologies, work-practices and as a result occupational requirements are subject to change. But they do illustrate a set of possibilities in terms of occupational outcomes given the data parameters currently at hand.

Exhibit 9: Indicative Occupational Employment Breakdown, Total Job-Years 2010-2030

BLS SOC code	Occupation Title	Total	% share
00-0000	Industry Total	7,961,943	
11-0000	Management Occupations	581,301	7.3%
13-0000	Business and Financial Operations Occupations	385,439	4.8%
15-0000	Computer and Mathematical Occupations	260,584	3.3%
17-0000	Architecture and Engineering Occupations	478,276	6.0%
19-0000	Life, Physical, and Social Science Occupations	21,672	0.3%
21-0000	Community and Social Service Occupations	0	0.0%
23-0000	Legal Occupations	86,192	1.1%
25-0000	Education, Training, and Library Occupations	79	0.0%
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	612	0.0%
29-0000	Healthcare Practitioners and Technical Occupations	2,441	0.0%
31-0000	Healthcare Support Occupations	0	0.0%
33-0000	Protective Service Occupations	36,649	0.5%
35-0000	Food Preparation and Serving Related Occupations	1,346	0.0%
37-0000	Building and Grounds Cleaning and Maintenance Occupations	182,243	2.3%
39-0000	Personal Care and Service Occupations	-192	0.0%
41-0000	Sales and Related Occupations	219,952	2.8%
43-0000	Office and Administrative Support Occupations	841,154	10.6%
45-0000	Farming, Fishing, and Forestry Occupations	607	0.0%
47-0000	Construction and Extraction Occupations	1,093,178	13.7%
49-0000	Installation, Maintenance, and Repair Occupations	1,091,714	13.7%
51-0000	Production Occupations	2,008,104	25.2%
53-0000	Transportation and Material Moving Occupations	669,740	8.4%

Note: Occupational definitions as per the BLS's Standard Occupational Classification (SOC) system
Forecasts are derived using the DBCCA Electricity Power Forecasts, the WPK model and related research on occupational breakdowns for the RE, EE, gas, coal, nuclear and related power supply sectors

This table represents the sum of the cumulative job-years of direct and indirect employment expected over the forecast period. These are net figures, that include the expect losses in coal sector O&M employment as a result of the retirement of coal plants. Excluding the impact of any induced jobs, then the majority of the jobs created will be, as expected, in the construction, installation, production, maintenance, repair, engineering, and related project management areas. As already mentioned, many of these jobs are well paid occupations for skilled and professional workers.

Implications for Policy-Makers

These forecasts have a number of important policy making implications:

- A secure and cleaner energy future for America is accompanied by valuable job creation.

- While estimating costs is difficult, natural gas is competitive and we believe that renewable energy sources will reach grid parity in the next 5-10 years. In effect, incentives are working to reduce costs due to "learning by doing" as industry scales up and so have a finite time frame in sight (see more discussion in the companion white paper *Natural Gas and Renewables: The Coal to Gas and Renewables Switch is On!).*

- There will be implications for those who currently work in the coal sector as reliance upon coal power declines and that of gas increases. These workers will need to find new jobs or be re-trained. Not all new gas plants can be placed where existing coal fired power plants will be decommissioned. So there are job market implications at the State level (including fuel supply, like coal mining and coal transportation).

- Federal, State and Local government policy planners need to allow for new gas pipeline infrastructure and electricity transmission networks so that the proposed new RE and gas plants can feed their power to end users. Although some of this work is now already underway in anticipation of the new power supply sources, more planning will be needed so that these infrastructure investments can be put in place on a timely basis.

- Whilst RE and the coal/gas switch related investment initiatives will have important local and regional employment impacts given that solar and wind installations cannot be sited anywhere, most regions in the US have some RE resources and EE jobs are not regionally dependent.

- From a scenario perspective it is also interesting to see if we assume a BAU (business as usual) case for energy demand over the forecast period and no improvement in EE as included in the DBCCA outlook, then this would mean energy demand will be higher. As a result, we will lose the jobs created by the EE initiatives and at the same time need more RE and gas supply. We would also then have greater resulting loses in coal. Indeed the overall cost impact would be more negative. So, from a policy-maker perspective, EE initiatives seem like a win-win option.

The Modeling Methodology – How we Generated our Forecasts

There are a number of ways to approach forecasting the employment impact of a set of energy supply/demand forecasts.

In a perfect world, the process starts with how much power supply is needed over the forecast period then estimates the number and types of power supply sources needed. If there is a location for each power supply source/plant and how much it will cost to build, this is complete. This data can be put into a complex macroeconomic model and generate a set of employment outcomes. If the economic model is detailed enough then it may also be able to provide a state-by-state breakdown of employment impacts and maybe also occupational data by state. This is certainly possible, but does require a very complex model and an enormous amount of data inputs and assumptions. There has been some research along these lines (e.g. The Perryman Group looking at the Texas renewables markets, and others have done similar sector/regional specific exercises using detail I-O models like IMPLAN) but we have not seen anything to date that covers all RE sources, EE initiatives, the switch from coal to gas, and the related pipeline and transmission line investments, in one model, from a national economy-wide perspective.

Furthermore, because the current set of occupational labor market data used in many U.S. economic models does not yet reflect the specific types of employment related to new energy sectors like solar, wind, geothermal etc, it is still necessary to make occupational assumptions on how to match the new occupations with the current set of occupations (trying to get a close a skill-set match as possible).

After reviewing more than 35 reports on the employment impacts of cleaner energy investments we found that a model created by **Wei, Patadia and Kammen (WPK),** from the Energy Resource Group at the University of California, Berkeley provided us with a simple but rigorous methodology that allows us to model job creation at a high level of definition from a set of energy supply/demand forecasts. To this we then have to apply a set of assumptions to reach industry level categories for the employment and also added our forecasts for related gas pipeline and power transmission line investments assumed in our energy outlook

The November 2009 study by **Wei, Patadia and Kammen (WPK)** *("Putting renewable and energy efficiency to work: How many jobs can the clean energy industry generate in the U.S.?"*) provides a useful and easy to use model to forecast job creation assuming a mix of renewable energy sources, energy efficiency assumptions, utilization of low carbon sources and nuclear energy.

The WPK model itself is derived from a meta-study of 15 key job studies and produces normalized direct employment multipliers per unit of energy that can be applied to an energy forecast scenario (see later for further details). These studies were a combination of input-output "top-down" approaches or analytical "bottom-up" approaches.

An important feature of the model is that it allows various RE and low carbon power supply scenarios to be modeled and also see how changes in fossil fuels usage and EE will impact jobs. For example, the switch from coal to gas can be modeled and the outputs will reflect not only the gas related new jobs needed but also the coal-related implied job losses.

So, starting with a forecast of the energy supply needs and knowing your desired energy supply composition, this model can provide quickly a set of job creation outcomes encompassing jobs involved in the construction, implementation, manufacture (CIM) phase of the required new investments and ongoing operation, maintenance and fuel supply phase (O&M).

At the core of the model is the concept of job-years, a term used in many other research reports on this topic. Although it is common to speak of a job in terms of employment for a person on an ongoing basis, when it comes to investments in new power supply sources one has two types of employment: the CIM jobs last for as long as it takes the plant to be built and become operational. For a gas plant, this could be 2-3 years; for a solar PV installation it could be 1 year (or less). When operational, the ongoing O&M jobs last for the lifespan of the installation (e.g. 40 years for a gas plant, say 25 years for a solar PV installation).

In the CIM phase, the project may need 300 people working full-time for 3 years. In terms of job-years, this means 300 x 3 = 900 job-years of employment. Thereafter, the plant runs for 40 years and requires say 10 people to operate it and say another 20 say to supply the fuel, maintain the pipes etc. Total O&M is 30 people working over 40 years: 30 x 40 = 1,200 job-years.

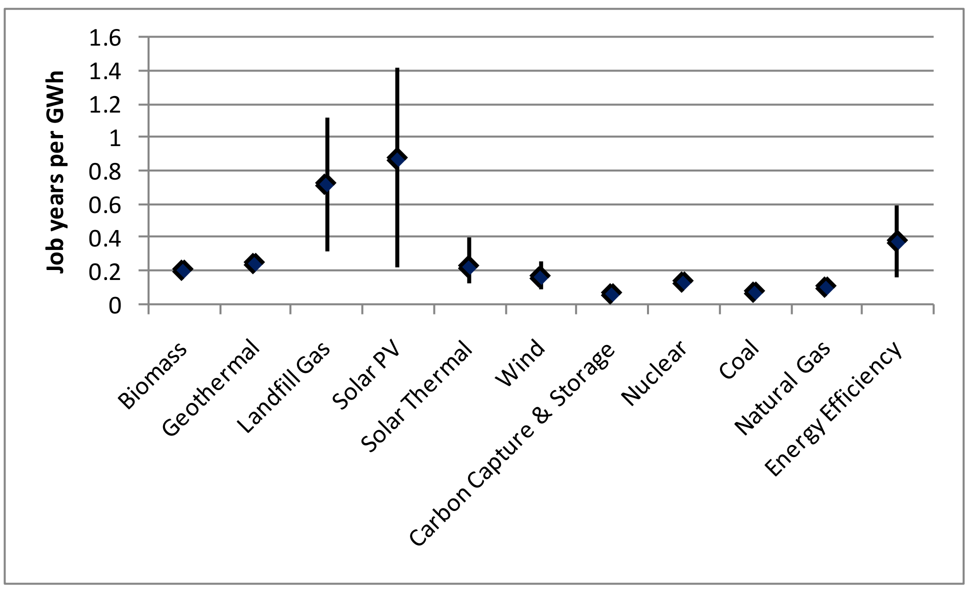
So, although the plant's construction required 300 new jobs (each lasting 3 years) and then 30 O&M jobs thereafter, total 330 jobs, in fact the comprehensive way to look at the employment effect is via the job-years required: 900 CIM + 1,200 O&M = 2,100 total job-years of employment over the life of the facility.

Knowing how many GWh the plant is producing, its efficiency rate of operation, and its expected operational lifespan, it is possible to convert each of these job-years figures into a "job-years per GWh of energy produced". Add the CIM job-years per GWh to the O&M job-years per GWh, and then the result is an aggregate job-years GWh multiplier for the installation.

This can be done for each power supply technology. The result is a set of job multipliers for solar, wind, geothermal, gas, coal etc. Given a power supply forecast, it is possible to then calculate the total employment that is implied for each power supply technology and for an energy supply outlook overall.

This graph illustrates the range of employment multipliers associated with various power supply sources, with the marker showing the average multipliers from the WPK meta-study.

Exhibit 10: Average and Range of Employment Multipliers for Different Energy Technologies



Source: WPK model.

Solar PV has at present the highest employment multiplier, but also the widest range of estimate according to the WPK meta-study report. By contrast, coal has the lowest employment multiplier.

In terms of how the model works, the energy supply forecast is broken down into the percentage share coming from each technology. For each year, this gives a GWh of power supply coming from solar, wind, coal, gas etc. If 20,000 GWh is supplied by geothermal in 2012, if the total jobs multiplier for geothermal is 0.25 job-years per GWh (CIM and O&M combined), then for 2012 the implied job-years requirement for geothermal would be 20,000 x 0.25 = 5,000 job-years of employment (CIM and O&M) to generate this amount of power supply for that year. This is done for each energy supply source to generate the total job-years figure for each year in the forecast period.

The WPK model is useful as it can be run using one or more input assumptions. For example, examine various RE mix scenarios and assess what impact various energy efficiency assumptions have on the outlook. The model is additive – it can combine the resulting simulation results.

Whilst the authors of the model chose to report the total employment impact of changes in the energy sources supply mix between fossil fuels, RE, nuclear etc, the model does allow one to look at the employment impact of just solar, just wind, etc, which is what we wanted to do. Because the model also has separate inputs for the CIM and O&M employment multipliers it is also possible to run the model with just one or the other employment multiplier input factors operating. That means we can look at solar CIM employment separate from solar O&M employment, wind CIM employment separate from wind O&M employment, etc. This is useful, as CIM has different occupational employment implications from O&M.

The WPK model highlights that, as expected and confirmed in other studies, that:

- RE and low carbon sources can generate more jobs per unit of delivered energy than traditional fossil-fuel based sources
- Amongst the RE technologies, at this time solar PV creates the most jobs per unit of electricity output
- Switching from coal to gas delivers more new ongoing gas jobs per GW added than those lost from removing one GW of coal powered capacity.
- Energy efficiency measures can be economically the least costly way to create jobs, reducing the need for additional new energy supply sources (be they RE, traditional fossil fuel plants, or low carbon sources).

In their report, the WPK model was used by the authors to compare a BAU (business as usual) scenario for energy demand and supply from the U.S. Energy Information Agency (EIA) vs. the author's assumptions on energy efficiency, and mix of energy supply sources (RE, low carbon, fossil fuel etc) through to 2030.

For the purpose of our research, we made a number of modifications to the model in terms of how it runs and presents the results:

In simple terms we made the following additions and deletions:

- Given that indirect job creation will vary widely across RE technologies and that data on this is harder to come by than direct job creation, the authors for their model assumed a flat 0.9 indirect multiplier for all energy technologies for the sake of simplicity. So, for example, if the direct jobs multiplier is 0.2 job-years/GWh, then the indirect jobs multipliers is 0.2 * 0.9 = 0.18 job-years/GWh resulting in total job-years of 0.38/GWh (0.2 + 0.18). This may well be a compromise solution – but acceptable given the resources needed in the absence of a very complex economic model get more precise figures.
- In terms of induced job creation, the WPK model includes this only for EE. Induced job creation estimates are typically hard to come by and may only be estimated by running a complex I-O model. As a result, we have left them out of the final total (and assumed only direct and indirect CIM jobs from EE initiatives). Indeed the model makes no comment about the cost-benefit impact of switching to new RE sources in terms of what this might mean for overall energy costs for consumers and business in certain locations, nor does it incorporate the fiscal impact associated with incentives designed to fast-track installation of new RE sources. Nor does the model incorporate any fiscal impacts as a result of new EE initiatives. Nor does it look at externalities. In a perfect world, one would have to allow for all this as well, but we do not believe any model can do this accurately at present.
- The WPK model assumes there are no distribution constraints in getting the new energy supply to its final use destination. This assumption is unrealistic to the extent that if RE and gas power replaces traditional fossil fuel supplies, then it is by no means guaranteed that the new power supply that is

created in one location can be fully utilized there. New distribution and transmission systems will be needed to get wind and solar from their ideal supply locations to residential and commercial users in large populated areas, likewise power from new gas plants to their users. We have attempted to capture this by using our assumption for the requirements of new gas pipeline and power transmission line infrastructure. We have incorporated this in our work by assuming a profile of pipeline and transmission line additions in line with our expected new power supply capacity additions.

- Furthermore, it is unavoidable that there will be some leakage of job creation into imports. We have already seen this in RE technologies like wind and solar. There will also be regional impacts of employment creation. Given that the WPK model does not allow for any imports leakage, we have tried to capture this by adjusting the jobs multipliers for an assumed leakage factor with respect the assumed manufacturing share of jobs required for that sector. For example, using recent research on this topic, we have assumed that 60% of the manufactured components that go into a solar installation are imported and in the case of wind, the imported share for manufactured components is 40%. As a result, we have tried not to overstate the domestic job creation impact from these sectors.
- The employment multipliers used in the model assume no change in technology, efficiency or productivity improvements. Clearly, these will occur, especially in new energy technologies like solar and wind. The cost curve is certain to decline. We have assumed that for solar PV the implied direct CIM jobs multiplier declines during the forecast period (-2% p.a.) given that it has the highest jobs multiplier in model and as such yields the greatest jobs.
- Our forecasts also capture the job creation impact of constructing the new gas pipelines and power transmission lines that will be needed as a result of our energy supply outlook through to 2030. We expect that around 30,000 miles of new power transmission lines will need to be built and a 10-12% expansion in the current gas pipeline infrastructure. Our job multiplier assumptions were 10.3 CIM job-years per mile to build transmission lines and 1.8 CIM job-years per mile of gas pipeline (source: Brattle/WIRES, NREL and industry feedback based new project installations
- Occupational breakdown – the model cannot explicitly provide this because although the underlying studies may have contained some occupational detail, the model is only using each study's aggregate jobs multiplier as an input. So, although the model may tell us 1,000 job-years of CIM input are required in 2012 for a gas plant installation to provide the assumed increase in gas fired electricity, to disaggregate this total CIM number into specific occupations, you need to apply some kind of occupational filter or screen that assumes a specific set of occupations that are required in the CIM phase of work. A number of researchers, like PERI (University of Massachusetts) have done this by, using industry survey data to construct a synthetic or hybrid RE sector by occupation. This is the approach we have used as well as it is the best way around the lack of specific occupational detail provided by the WPK model and the current lack of occupational data from the BLS for the RE , coal and gas power sectors.

Then we made a series of technical but important adjustments to how the model was run:

First, for the sake of simplicity, the model's authors have it being driven by a set of energy supply forecasts. They are assuming a BAU scenario (the EIA's latest Energy Outlook) as an input and changing the energy supply mix (e.g. more solar than BAU, less coal, more wind, etc.). Since they do not have specific forecasts on capacity additions by energy supply source, although these can be implied from their model, they are not looking at capacity additions as input, nor do they need it since they have a set of job multipliers expressed as job-years per GWh produced.

In our case, we have both an energy supply forecast as well as forecasts for specific capacity additions for RE, coal, gas, nuclear, etc.

Accordingly, we were able to add into the model our assumed capacity additions and check how they matched to the model's output in terms of implied capacity added each year.

Second, because the model needs to add a lifetime's measure of O&M employment (25-40 years) to a finite job input for the CIM phase (which could be 1-3 years), the authors chose to smooth or average the total CIM job-years requirement over the lifespan of the installation. For example, assume it takes 1,000 job-years of CIM labor to build and install a new gas fired plant. If the plant lasts for 40 years, the model assumes that the CIM job requirement over the life of the plant is an average of 25 jobs per year (1,000 job-years/40 years).

Although this is a perfectly valid and consistent approach, the authors agree that from a practical approach this smoothing or averaging of CIM jobs over the life of the plant means that over a shorter forecasting time frame than the plant's lifespan, by definition, you will be underestimating the total CIM job-years input.

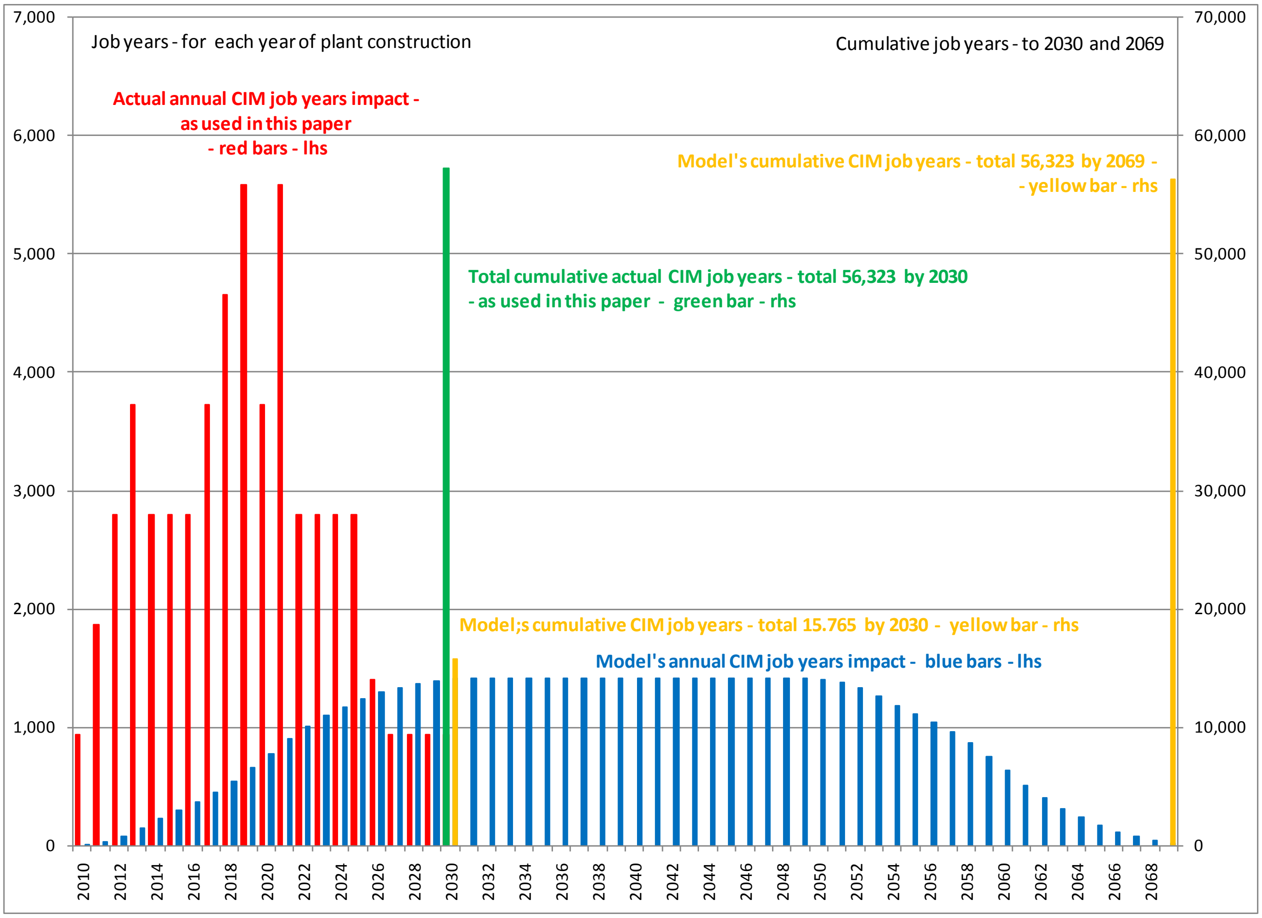
For example, if we assume the average CIM figure is 25 jobs per year over 40 years, and the plant is built in 3 years, then over a 20 year forecast period this will by definition understate total CIM employment by 50%. That is, we capture only 20 years x 25 jobs per year = 500 job-years during the first 20 year period. The remaining CIM jobs are reflected in the forecast period after 20 years.

In the light of this factor, and given we have capacity additions by power supply source, we decided it would make sense to effectively switch the averaging of CIM jobs off in the model. That is, rather than assume that the CIM jobs are allotted on a pro-rata yearly basis, based on the plant's expected lifespan; we will assume that each year's capacity addition is built in 1, 2, 3 or more years, depending on the technology. For example, using industry sources on projects completed, we have assumed solar installations are completed in 1 year; geothermal in 3 years, gas plants in 3 years, and around 6 years for the construction phase of a nuclear plant.

As a result, the model captures within our forecast timeframe (2010-2030) the full CIM jobs impact of any new plant capacity addition that was needed and could be completed in that time frame. So, if 6,000 GW of gas plant capacity was needed in 2010 and required 6,000 job-years to build, we assumed that the CIM jobs were required during 2010-2012 build phase and as such fully reflected in the forecast period through to 2030 (rather than averaged at a rate of 150 job-years per year during the period 2010-2030). Whereas the original model would reflect only 3,000 job-years of employment during 2010-2030 (150 job-years x 20 years), our modification allowed for the full 6,000 job-years to be reflected, which in our view is a more accurate assessment of the real-world impact of this type of investment.

So, whilst the WPK model in its original form would forecast around 0.9 million cumulative direct CIM job-years of employment over the 2010-2030 period, once the averaging is turned off, the net impact is large, with cumulative direct CIM employment closer to 3.0 million over the period. Doing this adjustment was necessary so as to more correctly reflect the likely jobs impact of the CIM work being done during the forecast period (2010-2030) whereas the model would by nature be capturing all these jobs, but only if looked at over the full lifespan of each new installation. The chart below illustrates the difference between averaging and not averaging for assumed increases in geothermal capacity. The lifespan of a geothermal plant is assumed to be 40 years. The red bars (lhs) denote the actual CIM impact of constructing each year's new capacity that is added, which what we use in our results. The blue bars denote the model's annual construction impact, assuming the construction impact is allocated over a 40 year plant lifespan. This illustrates that whilst in reality all the new plants are in place by 2030 (requiring 56.323 cumulative job-years of direct CIM employment (green bar, rhs)); the unadjusted model takes through to 2069 before it has completely allocated the averaged lifespan construction impact (also 56,323 job-years, yellow bar, rhs).

Exhibit 11: Impact of Difference between Job-Years Averaged over Plant Lifespan vs. Actual Build-Out



Source: WPK Model, DBCCA Analysis.

Third, we wanted to see the CIM and O&M jobs impact separately. So, whilst the model is driven by aggregate average jobs per GWh multipliers, it is possible to look at just the CIM or O&M components of this aggregate multiplier by switching either of them off, and then adding back the sum components.

Fourth, the model's output in terms of jobs estimates are given in terms of changes relative to a BAU baseline. In our case, we are interested in showing how many jobs are created as a result of our energy supply forecast and the capacity additions that this implies (by energy supply source). As a result, we have asked the model to calculate the job changes relative to our baseline starting point (2009), not just relative to the BAU energy supply outlook that is in the model (i.e. the U.S. EIA 2011 Energy Outlook). In our view this gives a more realistic jobs number to explain since we are reporting job additions relative to now vs. some other implied trajectory

Fifth, given the model assumes fixed job multipliers over the forecast period, it is not allowing for technical innovation or productivity gains that may lower the jobs multiplier over time. In the case of solar PV, whilst the model assumes an average 25.49 job-years per MWp of installed capacity (which is an average of the survey inputs used by the model's authors), we took the view that for solar PV to become more accepted and widely used as our forecasts assume, the cost curve on solar PV will need to come down. While solar PV's CIM labor-intensity will always be higher than for other RE technologies, we have assumed that the jobs-multiplier will fall by 2% per annum over the forecast period.

Sixth, whilst the model assumes that 10% of EE employment creation will be direct CIM jobs and the remainder (90%) induced employment, given that modeling induced employment impacts are difficult without a highly detailed I-O model, we chose to incorporate only the direct and indirect jobs CIM these would result in. Given that we assume that the majority of EE related work will be in areas like weatherization, we have assumed a modestly higher share of job creation being direct CIM (20% vs. 10% in the original WPK model), As a result, we are capturing only EE CIM related job creation (direct and indirect) and ignoring the large remainder which is induced.

Finally, given that the model projects job-years of employment by year, it is possible to look at the year-by-year changes in implied employment by power supply sector. So, for 2030 (or any year in between), the implied level of employment can be derived as the energy supply forecast changes.

Notwithstanding the above provisos associated with the WPK model, from a conceptual, empirical and practicality perspective, it does in our view provide an easy to use and understand modeling methodology when you want to assess the total aggregate employment impact of various energy supply scenarios. For our modeling needs, having an energy outlook forecast as our primary input, this model provides the best job forecasting framework we could use for this report and has allowed us to make a number of necessary modifications to enhance the reporting of our results.

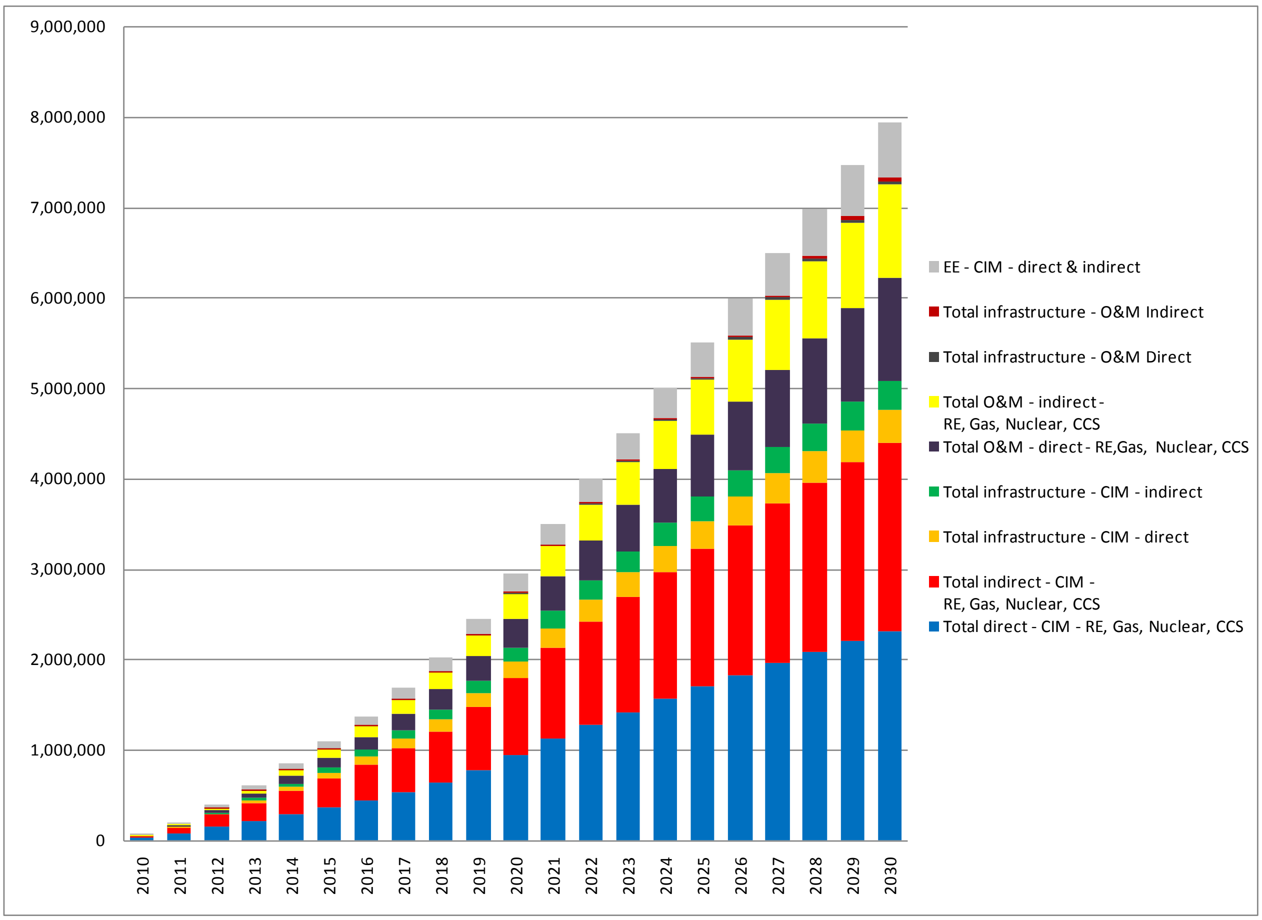
The Model Results using the DBCCA Energy Outlook Forecasts

Having switched off the model's assumed lifespan averaging of CIM jobs and having assumed ongoing labor productivity improvements with respect to solar PV installations, and including the required gas pipeline and power transmission line investments, we are able to forecast 7.9 million cumulative job-years of employment over the period 2010-2030 accompanied by a net 486,000 new jobs in place by 2030.

The dynamic of the cumulative jobs growth can be easily seen in the accompanying charts.

Exhibit 12 below details the breakdown of the cumulative growth in job-years – of 7.9 million by 2030. The largest share is driven by the CIM phase of building the new power supply sources as well as the gas pipeline and power transmission line infrastructure that is needed to accompany them. This totals about 5.1 million job-years of employment over the period 2010-2030. The balance is made up of O&M related jobs (direct and indirect), totaling around 2.2 million job-years of employment, with EE related initiatives providing the remaining 0.6 million job-years of employment.

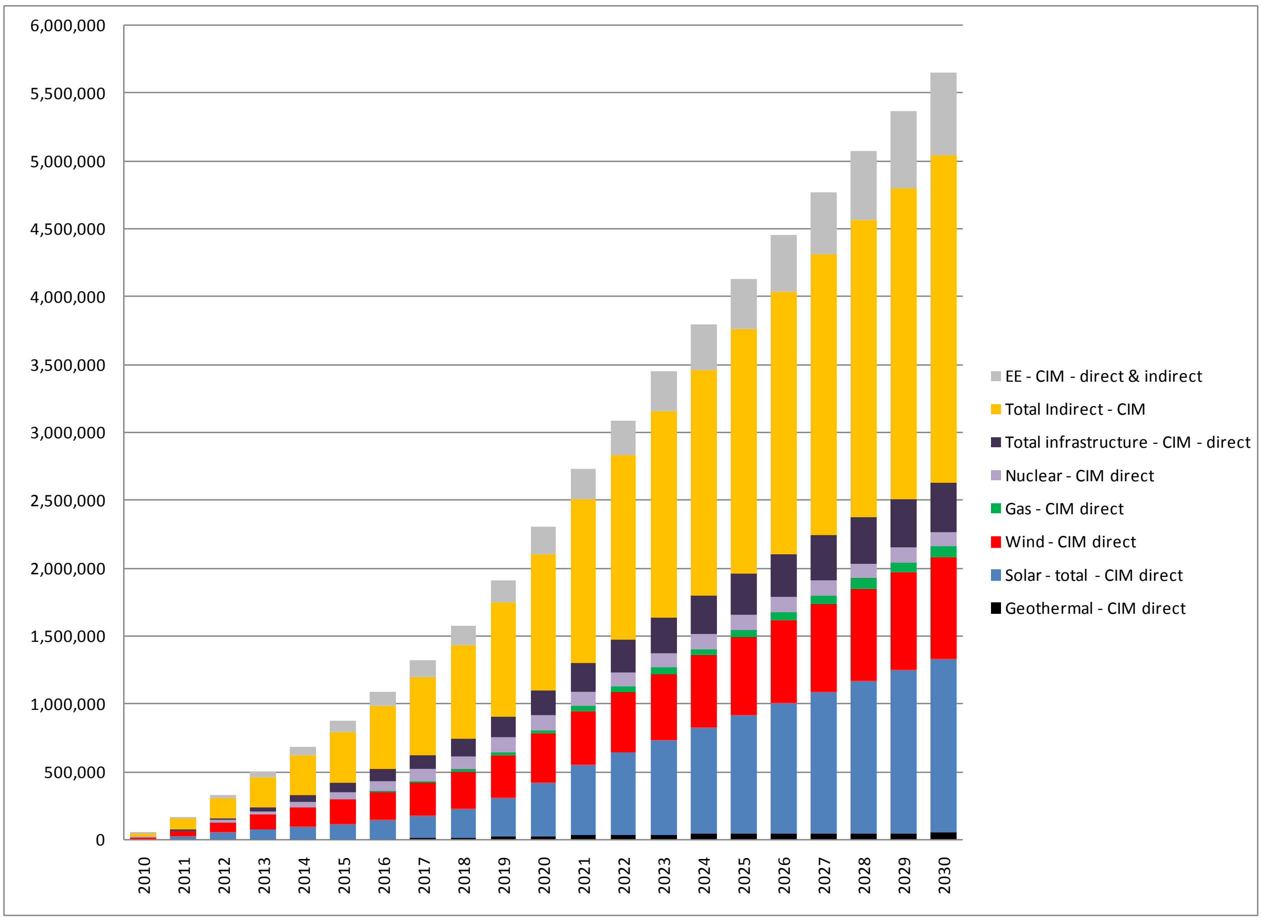
Exhibit 12: Cumulative Jobs Growth, 2010-2030: Job-Years of Full Time Employment



Source: WPK Model, DBCCA Analysis.

Exhibit 13 below details the breakdown by sector of the cumulative CIM related job-years during the period of 2010-2030. Including the jobs that come from EE (direct and indirect), this adds up to around 5.7 million job-years of employment.

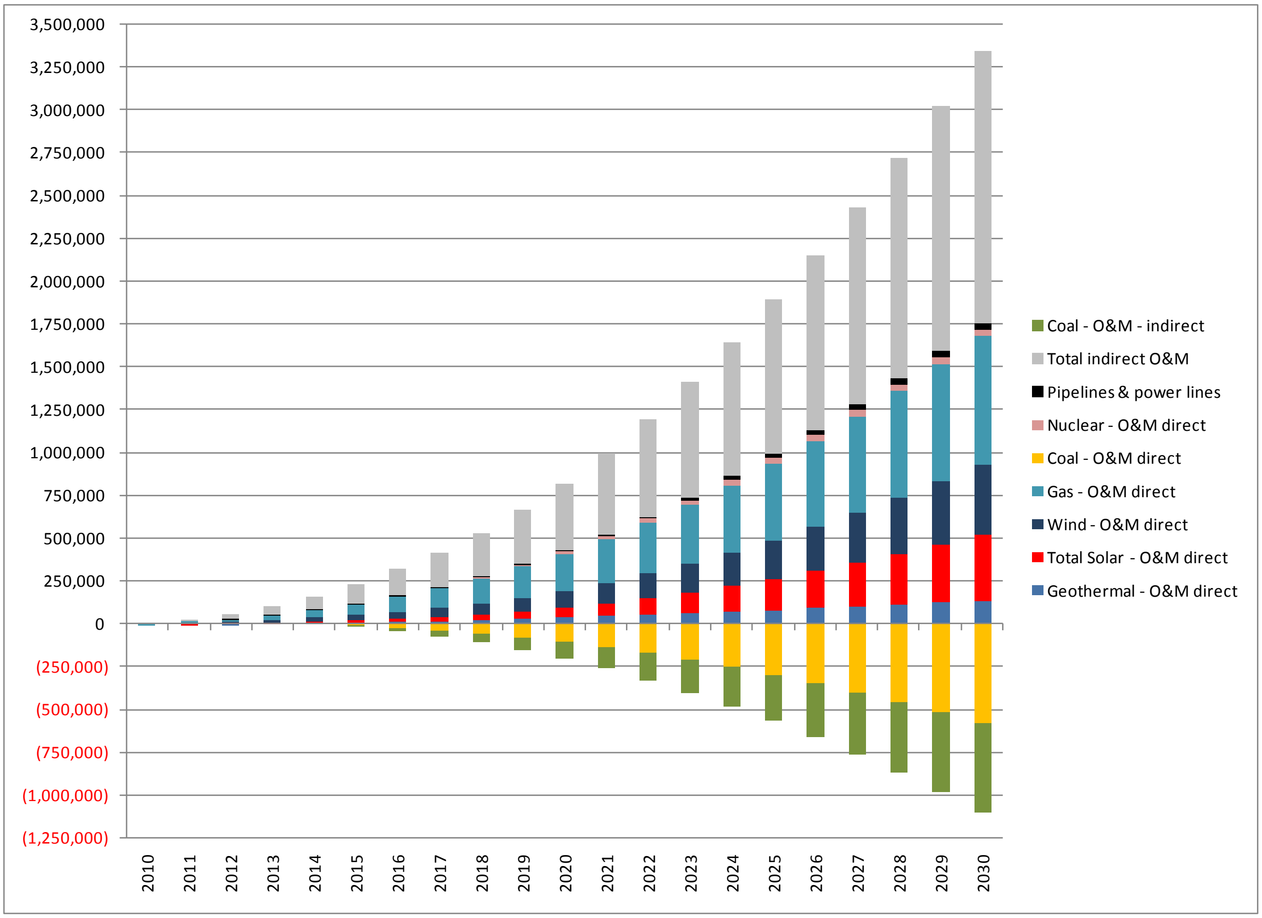
Exhibit 13: Cumulative CIM Jobs Growth (by sector), 2010-2030: Job-Years of Full-Time Employment



Source: WPK Model, DBCCA Analysis.

Exhibit 14 below details the cumulative growth in O&M job-years. By 2030, the net cumulative increase is around 2.2 million job-years of employment, which includes the assumed job losses in the coal sector as existing plant retirements take effect.

Exhibit 14: Cumulative O&M Jobs Growth (by sector), 2010-2030: Job-Years of Full-Time Employment

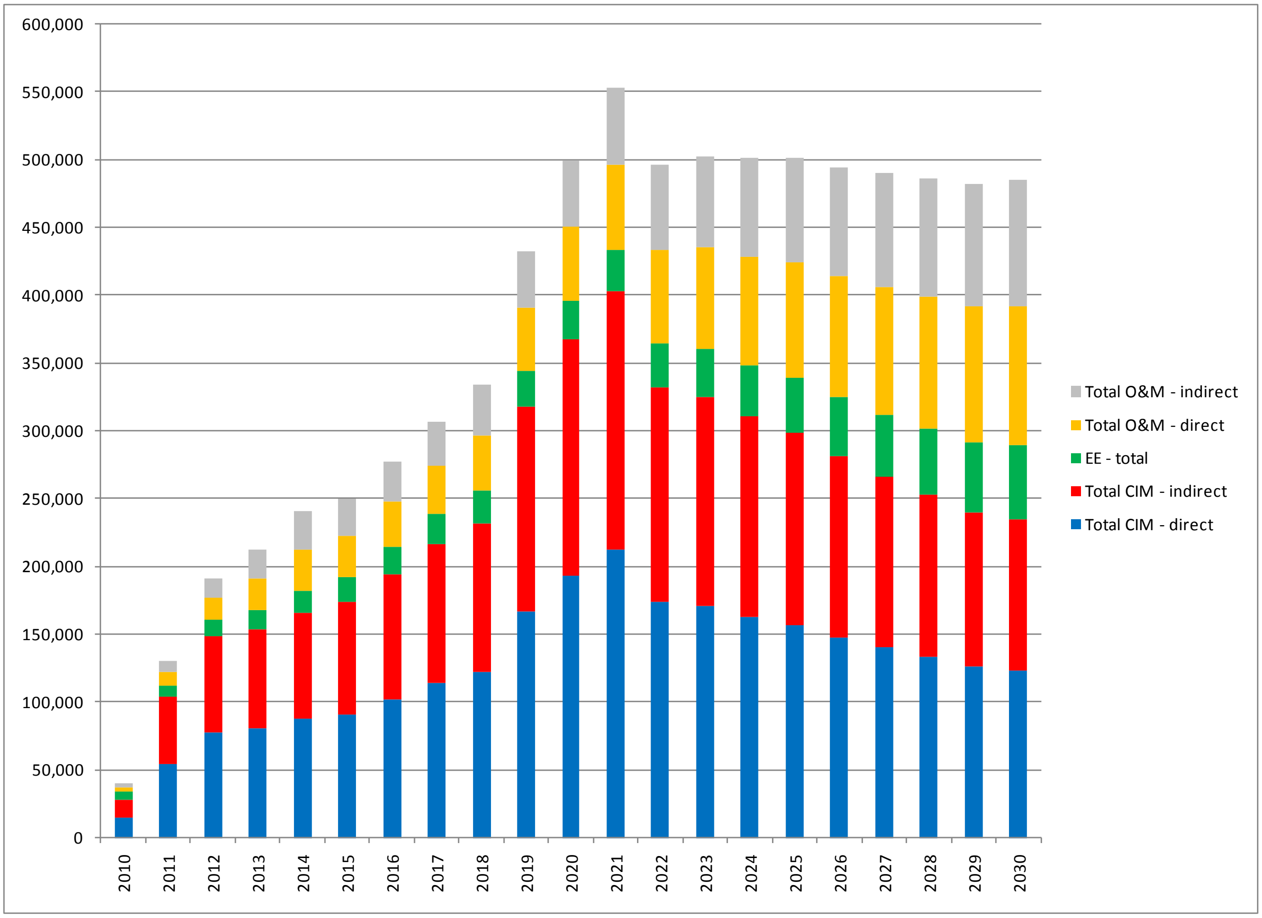


Source: WPK Model, DBCCA Analysis.

Another way to view the result is to look at the **yearly jobs impact** (vs. job-years). *How many jobs are created in each year of the forecast, by type and by sector?* Using this approach you can see the peak and decline in CIM related jobs and the steady rise in O&M jobs and EE related jobs.

Exhibit 15 below splits out the CIM and O&M jobs created each year in the forecast period, direct vs. indirect, as well as the total jobs created by the EE initiatives. As the CIM phase winds down in the second half of the forecast period, jobs continue to be added on the O&M side and also as a result of EE initiatives. The total number of new jobs added at the end of the forecast period is around 486,000.

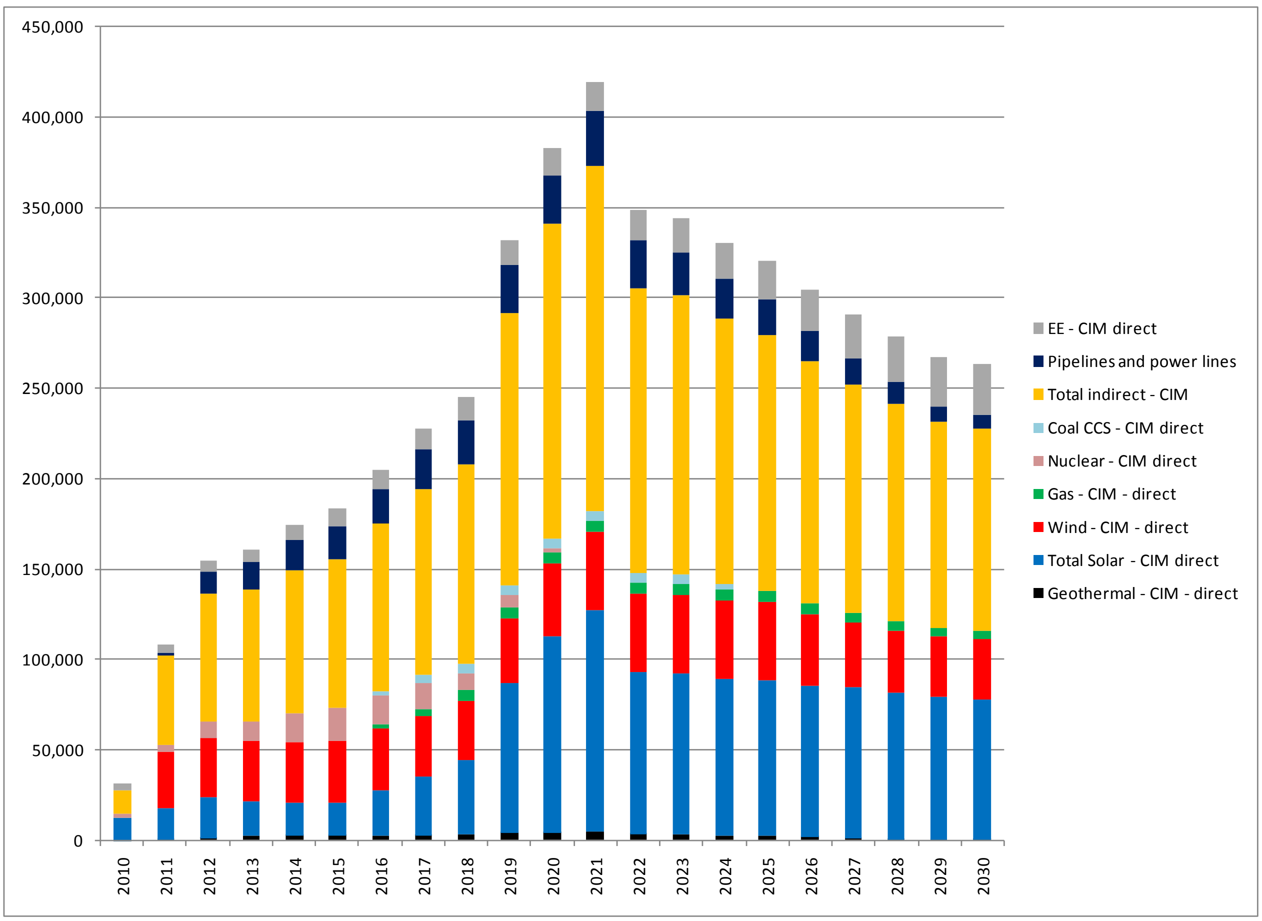
Exhibit 15: Annual Net Job Additions (by sector and type)



Source: WPK Model, DBCCA Analysis.

Exhibit 16 below details the composition of the CIM jobs, by sector. The job creation impact of solar PV is clearly visible, reaching a peak around 2020-21 and then tailing off thereafter. The contribution of solar is larger than for other RE supply sources because its installation by nature is more labor intensive. This is even despite the fact we have assumed a large import share for its manufactured components and a 2% annual improvement in labor installation productivity. We also show the jobs created by the currently planned nuclear plant additions as well as some modest coal CCS investments.

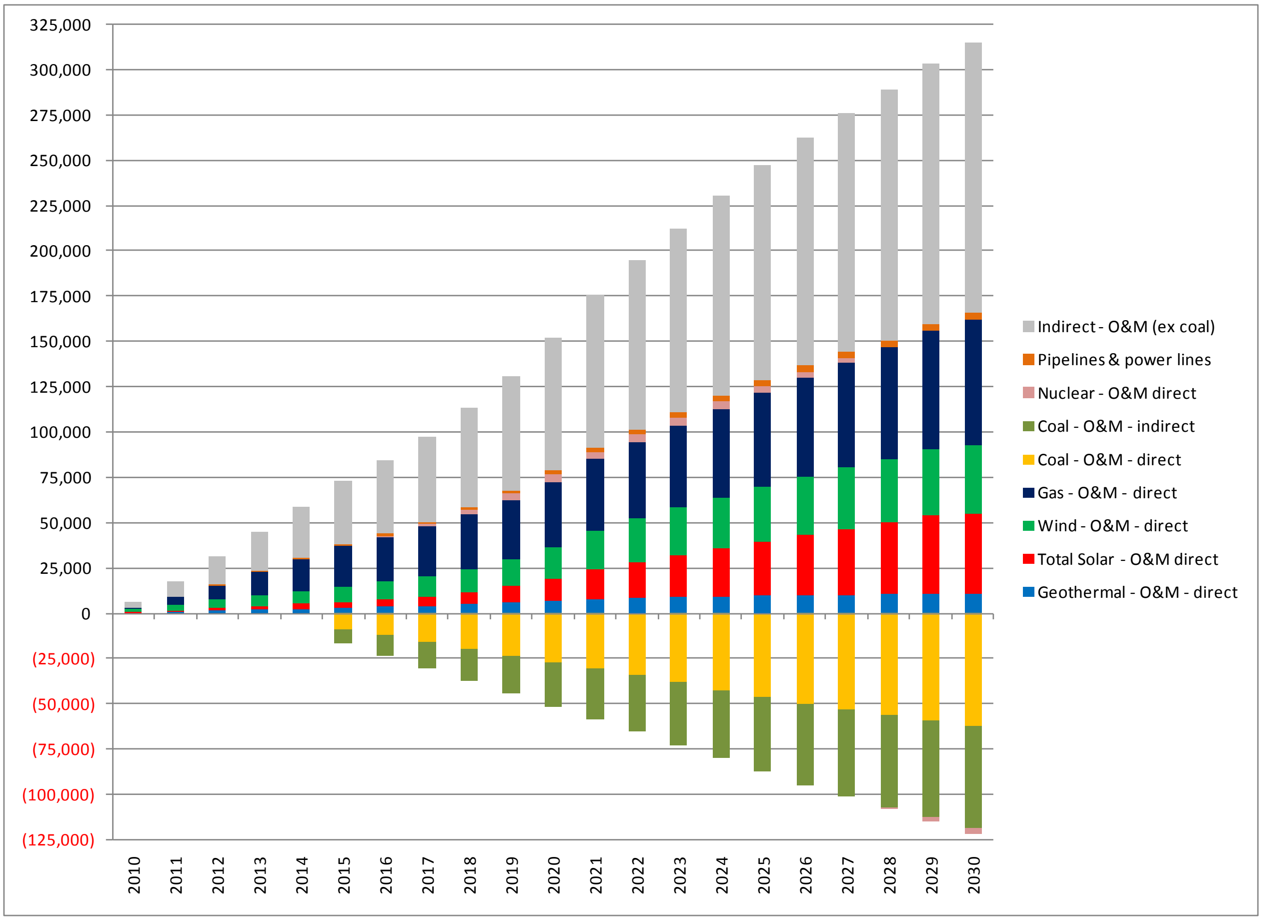
Exhibit 16: Annual Change in CIM Jobs (by sector) - Direct and Indirect



Source: WPK Model, DBCCA Analysis.

Exhibit 17 below details the composition of the O&M jobs, by sector. By 2030, we have a net increase in O&M jobs of about 196,000. We gain about 320,000 O&M jobs from RE, new gas supply sources, and related new gas pipeline and power transmission line infrastructure maintenance, but lose about 119,000 from the coal sector (direct O&M and indirect related jobs), with a small loss as well from nuclear as those plants also start to be retired after 2025.

Exhibit 17: Annual Change in O&M jobs (by sector) - Direct and Indirect



Source: WPK Model, DBCCA Analysis.

Occupational breakdown of the forecast employment growth

It is important to find out what types of jobs will a switch towards increased RE, from coal to gas, and increased focus upon EE will result in. What are the new occupations that need to be filled, where will these jobs be, how many, and what sort of training/re-training is needed to fill them?

In researching this area it is quickly apparent that although a lot has been written about general job opportunities associated with the cleaner economy or specifically cleaner energy investments, when it comes to solid and reliable data on occupational breakdowns, there is a dearth of analyses. Clearly, a lot more work needs to be done in this area, although this likely cannot be done completely until the BLS releases it first surveys on employment in the green economy in 2012.

There are two reasons for this lack of data and analysis. First, industries like solar, wind, geothermal are relatively new and official statistics have not yet identified them as distinct industries for which to collect regular data on total employment and employment by occupation. Second, where research has been done, it has typically been targeted towards identifying businesses that operate in solar, wind etc, and “guesstimating” employment for that industry from those companies. Few have taken the next step to then numerate the types of occupations involved. Third, even when researchers have looked at occupations, their definitions have varied, so you cannot reply upon uniform occupational classifications. There is no standard agreed taxonomy on green occupations.

In fact, in drilling down into the occupations involved in industries like solar, wind, gas, etc, typically it is found that most the of the jobs are filled by people with existing occupations. For example, there may be an electrician who is now installing solar panels. According to the BLS this work is classified and counted under the occupation “electrician”. Although this electrician may well consider himself now a “solar PV electrician”, according to the BLS this work by a solar PV electrician is not considered sufficiently different to work done by a normal electrician. So, in the eyes of the official statistics, this solar electrician is counted as an “electrician”. But in the eyes of a solar industry survey, he is counted as a “solar PV electrician”. This gives an insight into some of the complexities that arise when attempting to assemble a consistent set of numbers on occupational classifications for the cleaner energy supply industries

Given that the WPK model has allowed us to model employment growth by power supply sector and allows us to split the total employment numbers into CIM and O&M, direct and indirect, we estimated the occupational breakdown using the following approaches.

(Please see Appendix for a further overview of methodology.)

Indirect Employment: given that, in the absence of specific industry data, it would be very complicated to identify the precise industry linkages between each industry involved in the direct CIM phase and their indirect suppliers (and likewise for O&M) we adopted the following approach: we took the BLS occupational breakdown for the economy and removed all occupations that would not be related to the CIM supply chain in terms of indirect inputs. This involved removing the public sector and numerous private sector service occupations (like health care, hospitality, entertainment etc.) as well as construction and installation specific occupations that are already covered in the direct CIM breakdown. What remains is a profile of employment, by occupation, that would match the supply-chain of businesses involved in supplying the direct CIM phase of the power plant investment. For example, we would be picking up the steel supplier who is servicing the wind turbine blade manufacturer or the valve manufacturer who sends part to the gas turbine manufacturer, etc. We applied this resulting occupational breakdown to the total indirect cumulative jobs forecast output by the WPK model. In the absence of super-detailed and complex I-O model, we cannot see a better solution for this. But the results are intuitively sensible because they show a production bias in the resulting occupational employment breakdown. Using this approach, for indirect employment we have derived the following occupational forecast outlook.

Exhibit 18: Occupational Breakdown for Total Indirect Employment – cumulative for period 2010-2030

BLS SOC code	Occupation title	Job-years	% - total
11-0000	Management Occupations	311,716	8.3%
13-0000	Business and Financial Operations Occupations	203,220	5.4%
15-0000	Computer and Mathematical Occupations	203,717	5.4%
17-0000	Architecture and Engineering Occupations	226,708	6.0%
19-0000	Life, Physical, and Social Science Occupations	0	0.0%
21-0000	Community and Social Service Occupations	0	0.0%
23-0000	Legal Occupations	81,604	2.2%
25-0000	Education, Training, and Library Occupations	0	0.0%
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	0	0.0%
29-0000	Healthcare Practitioners and Technical Occupations	0	0.0%
31-0000	Healthcare Support Occupations	0	0.0%
33-0000	Protective Service Occupations	32,309	0.9%
35-0000	Food Preparation and Serving Related Occupations	0	0.0%
37-0000	Building and Grounds Cleaning and Maintenance Occupations	48,012	1.3%
39-0000	Personal Care and Service Occupations	0	0.0%
41-0000	Sales and Related Occupations	60,746	1.6%
43-0000	Office and Administrative Support Occupations	434,226	11.5%
45-0000	Farming, Fishing, and Forestry Occupations	0	0.0%
47-0000	Construction and Extraction Occupations	154,023	4.1%
49-0000	Installation, Maintenance, and Repair Occupations	289,765	7.7%
51-0000	Production Occupations	1,170,377	31.1%
53-0000	Transportation and Material Moving Occupations	545,804	14.5%
00-0000	All Occupations	**3,762,226**	100.0%

Note: Occupational definitions as per the BLS's Standard Occupational Classification (SOC) system
Forecasts are derived using the DBCCA Electricity Power Forecasts, the WPK model and related
research on occupational breakdowns for the RE, EE, gas, coal, nuclear and related power supply sectors

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Direct Employment: Next, in terms of the occupational breakdown of the direct jobs created through the geothermal, solar, wind, coal and gas sectors we used either industry data if available or constructed a synthetic hybrid occupational breakdown that seeks to replicate the types of occupations most likely to be used in each sector. In doing so, we selected the most relevant NAICS industry sector, removing occupations that may not be relevant to the specific CIM or O&M phase for each sector. For example, tertiary occupations like health care, entertainment, education, etc. were disregarded when constructing these hybrid occupational breakdowns since these occupations are unlikely to be relevant to the business involved in the indirect supply chain to the CIM or O&M phases For energy efficiency, we apply estimates from research reports that had looked at the occupational breakdown of energy efficiency.

The results of this analysis give the following occupational breakdown for the total direct CIM and O&M employment over the period 2010-2030.

Exhibit 19: Occupational Breakdown for Total Direct Employment – cumulative for period 2010-2030

BLS SOC code	Occupation Title	CIM direct	O&M direct	Total direct	% share
00-0000	Industry Total	3,019,007	1,180,710	**4,199,716**	
11-0000	Management Occupations	188,590	80,995	269,585	6.4%
13-0000	Business and Financial Operations Occupations	92,401	89,819	182,220	4.3%
15-0000	Computer and Mathematical Occupations	39,447	17,421	56,867	1.4%
17-0000	Architecture and Engineering Occupations	172,483	79,085	251,568	6.0%
19-0000	Life, Physical, and Social Science Occupations	2,316	19,355	21,672	0.5%
21-0000	Community and Social Service Occupations	0	0	0	0.0%
23-0000	Legal Occupations	1,132	3,457	4,589	0.1%
25-0000	Education, Training, and Library Occupations	25	54	79	0.0%
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	1,176	-564	612	0.0%
29-0000	Healthcare Practitioners and Technical Occupations	862	1,580	2,441	0.1%
31-0000	Healthcare Support Occupations	0	0	0	0.0%
33-0000	Protective Service Occupations	1,880	2,460	4,340	0.1%
35-0000	Food Preparation and Serving Related Occupations	1,620	-273	1,346	0.0%
37-0000	Building and Grounds Cleaning and Maintenance Occupations	13,449	120,781	134,230	3.2%
39-0000	Personal Care and Service Occupations	21	-213	-192	0.0%
41-0000	Sales and Related Occupations	67,965	91,242	159,207	3.8%
43-0000	Office and Administrative Support Occupations	256,205	150,723	406,928	9.7%
45-0000	Farming, Fishing, and Forestry Occupations	607	0	607	0.0%
47-0000	Construction and Extraction Occupations	942,129	-2,974	939,155	22.4%
49-0000	Installation, Maintenance, and Repair Occupations	306,814	495,135	801,949	19.1%
51-0000	Production Occupations	771,388	66,339	837,727	19.9%
53-0000	Transportation and Material Moving Occupations	158,300	-34,364	123,936	3.0%

Note: Occupational definitions as per the BLS's Standard Occupational Classification (SOC) system
Forecasts are derived using the DBCCA Electricity Power Forecasts, the WPK model and related research on occupational breakdowns for the RE, EE, gas, coal, nuclear and related power supply sectors

We now look at the direct job creation in the sectors one by one.

Energy Efficiency: with respect to direct CIM EE jobs, typically, these initiatives are involved with reducing the energy consumption in a residential, business or manufacturing environment. This would include projects like weatherization, more efficient heating and cooling systems, etc. As a result we have applied an occupational breakdown as per work done by the Donald Vial Center on Employment in the Green Economy, 2011 („*California Workforce Education and Training Needs Assessment For Energy Efficiency, Distributed Generation, and Demand Response*"). The resulting occupational breakdown is shown here in Exhibit 20:

Exhibit 20: Occupational Breakdown for EE CIM Employment – cumulative for period 2010-2030

BLS SOC code	Occupation Title	CIM - direct	% total
00-0000	Industry Total	342,806	
11-0000	Management Occupations	38,011	11.1%
13-0000	Business and Financial Operations Occupations	15,786	4.6%
15-0000	Computer and Mathematical Occupations	9,122	2.7%
17-0000	Architecture and Engineering Occupations	22,286	6.5%
19-0000	Life, Physical, and Social Science Occupations	1,008	0.3%
21-0000	Community and Social Service Occupations	0	0.0%
23-0000	Legal Occupations	436	0.1%
25-0000	Education, Training, and Library Occupations	0	0.0%
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	0	0.0%
29-0000	Healthcare Practitioners and Technical Occupations	0	0.0%
31-0000	Healthcare Support Occupations	0	0.0%
33-0000	Protective Service Occupations	0	0.0%
35-0000	Food Preparation and Serving Related Occupations	1,362	0.4%
37-0000	Building and Grounds Cleaning and Maintenance Occupations	912	0.3%
39-0000	Personal Care and Service Occupations	0	0.0%
41-0000	Sales and Related Occupations	10,803	3.2%
43-0000	Office and Administrative Support Occupations	11,934	3.5%
45-0000	Farming, Fishing, and Forestry Occupations	0	0.0%
47-0000	Construction and Extraction Occupations	198,774	58.0%
49-0000	Installation, Maintenance, and Repair Occupations	22,189	6.5%
51-0000	Production Occupations	10,138	3.0%
53-0000	Transportation and Material Moving Occupations	0	0.0%

Note: Occupational definitions as per the BLS's Standard Occupational Classification (SOC) system
Forecasts are derived using the DBCCA Electricity Power Forecasts, the WPK model and related
research on occupational breakdowns for the RE, EE, gas, coal, nuclear and related power supply sectors

Geothermal: The Geothermal Energy Association (GEA) in October 2010 published a detailed survey of its member organizations. This report provides not only total employment estimates, but also an occupational employment breakdown for most of the work that is required for a geothermal power plant investment. Using this data means that our 56,323 cumulative direct CIM jobs would have the following occupational characteristics:

Exhibit 21: Geothermal Sector (CIM) Occupational Employment Breakdown, Cumulative 2010-2030

Occupation / Job	Total	% share
EXPLORATION	**1,203**	***2.1%***
Geologist	*113*	*0.2%*
Geophysicist	*113*	*0.2%*
Crew to Gather Data	*226*	*0.4%*
Geochemist	*75*	*0.1%*
GIS Specialist	*75*	*0.1%*
Exploration Driller	*376*	*0.7%*
Sample Analyst	*113*	*0.2%*
Consultants	*113*	*0.2%*
DRILLING	**2,933**	***5.2%***
Drilling Engineer	*188*	*0.3%*
Rig Hands or "Drill Men"	*1,278*	*2.3%*
Rig Site Manager	*113*	*0.2%*
Mud Logger	*226*	*0.4%*
Drilling Fluids Personnel	*226*	*0.4%*
Cementing Personnel	*602*	*1.1%*
Safety Manager	*75*	*0.1%*
Welder	*226*	*0.4%*
VENDOR DRILLING JOBS	**4,813**	***8.5%***
Casing Personnel	*338*	*0.6%*
Directional Drilling Personnel	*451*	*0.8%*
Well Logging Contractor	*150*	*0.3%*
Geologist	*489*	*0.9%*
Rig Transporter	*1,880*	*3.3%*
Fuel Transporter	*1,504*	*2.7%*
ENGINEERING, PROCUREMENT & CONSTRUCTION (EPC) - DESIGN PHASE	**3,459**	***6.1%***
Degreed Engineer	*752*	*1.3%*
Plant Designer	*2,256*	*4.0%*
Document Controller	*150*	*0.3%*
Design Team Supervisor	*150*	*0.3%*
Admin. Support	*150*	*0.3%*
ENGINEERING, PROCUREMENT & CONSTRUCTION (EPC) - CONSTRUCTION PHASE	**29,327**	**52.1%**
Construction Manager		
Project Engineer		
Field Engineer		
Project Superintendent		
Safety Manager		
Document Controller		
Admin. Support		
Welder		
Assembly Mechanic		
Inspection Personnel		
Concrete Construction Operator		
Steel Erector		
General Construction Personnel		
MANUFACTURING	**14,588**	**25.9%**
TOTAL	**56,323**	**100.0%**

Note: Occupational classifications as as per Geothermal Energy Association surveys
Forecasts are derived using the DBCCA Electricity Power Forecasts and the WPK model

Although this GEA study did provide description of the jobs involved in the EPC (Construction) and Manufacturing phases, it did not provide a numerical breakdown of how many workers would be involved in each occupation in those phases. This sort of information could only be gathered by looking at case-studies of actual projects and using that data together with these category totals. So, we get an idea about the resulting occupations, but not the complete picture unless one did a wide range of case studies (assuming that private sector contractors would be willing to share this information).

In terms of Geothermal O&M employment, the GEA study also only gave an aggregate figure for how many O&M people are required for an indicative power plant operation. As a result, we have estimated geothermal O&M direct employment based upon indicative utilities operations employment requirements. This breakdown can be estimated using the BLS's current occupational estimates for the Utilities sector.

Exhibit 22: Geothermal Sector (O&M) Occupational Employment Breakdown, Cumulative 2010-2030

BLS SOC code	Occupation Title	O&M - direct	% total
00-0000	Industry Total	135,200	
11-0000	Management Occupations	8,599	6.4%
13-0000	Business and Financial Operations Occupations	9,721	7.2%
15-0000	Computer and Mathematical Occupations	3,826	2.8%
17-0000	Architecture and Engineering Occupations	14,385	10.6%
19-0000	Life, Physical, and Social Science Occupations	2,623	1.9%
21-0000	Community and Social Service Occupations	0	0.0%
23-0000	Legal Occupations	365	0.3%
25-0000	Education, Training, and Library Occupations	27	0.0%
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	568	0.4%
29-0000	Healthcare Practitioners and Technical Occupations	446	0.3%
31-0000	Healthcare Support Occupations	0	0.0%
33-0000	Protective Service Occupations	1,460	1.1%
35-0000	Food Preparation and Serving Related Occupations	0	0.0%
37-0000	Building and Grounds Cleaning and Maintenance Occupations	933	0.7%
39-0000	Personal Care and Service Occupations	0	0.0%
41-0000	Sales and Related Occupations	1,785	1.3%
43-0000	Office and Administrative Support Occupations	22,971	17.0%
45-0000	Farming, Fishing, and Forestry Occupations	0	0.0%
47-0000	Construction and Extraction Occupations	5,273	3.9%
49-0000	Installation, Maintenance, and Repair Occupations	40,520	30.0%
51-0000	Production Occupations	19,455	14.4%
53-0000	Transportation and Material Moving Occupations	2,231	1.7%

Note: the above occupational definitions are as per the BLS's Standard Occupations Classification (SOC) system.

Solar PV and Solar Thermal: The Solar Foundation published a report also in October 2010 "National Solar Jobs Census 2010". Although this report was an excellent attempt to: (i) quantify the total level of U.S. solar industry employment; (ii) identify the potential growth in employment over the next (based upon respondent expectations of their business activity levels); (ii) identify solar employment by state, and provide a sub-sector breakdown of this total employment (i.e. installation, manufacturing, wholesale trade, other); and (iv) identify in which occupations employment growth would be the strongest in the coming 12 months, the report unfortunately did not drill down further and quantify the types of jobs involved at the sub-sector level. That is, detail and enumerate what are the occupations currently involved in the solar installation sub-sector, in the solar manufacturing sub-sector, etc.

From our research, to date, no one has yet done this type of work. What has been published and is available is a listing of occupations involved, but not weighted % breakdown showing the mix of specific occupations that make up solar installation, solar manufacturing, solar wholesale trade etc. Until the BLS publishes its data Spring 2012, the only way to get this type of breakdown would be to either conduct another industry survey or in its place create a stylized indicative breakdown.

In terms of an indicative stylized breakdown, **PERI** (the Political Economy Research Institute at the University of Massachusetts) has taken this approach in some of their work on the employment impact of investments in the green economy. For example, the PERI reports have assumed that the solar industry comprises the following sub-sectors or industries:

- Construction - 30.0%
- Hardware manufacturing - 17.5%
- Electrical equipment - 17.5%
- Electronic components - 17.5%
- Scientific and technical services - 17.5%

They constructed these weightings using some industry data sources and using their own approximations of likely occupations used in the solar sector.

The PERI approach makes intuitive sense in the absence of more concrete industry or official data and we have followed their methodology. Using this methodology, we then referenced the existing BLS industry employment breakdowns for the above industries (or industries that are as closely related as possible to them) and then re-aggregated them by occupation. For solar (PV and CSP combined), the result is as follows:

Exhibit 23: Solar Sector Related Occupational Employment Breakdown, Cumulative 2010-2030

BLS SOC code	Occupation Title	CIM - direct	O&M direct	Sum total	% total
00-0000	Industry Total	1,277,587	389,825	**1,667,412**	
11-0000	Management Occupations	69,428	19,491	88,919	5.3%
13-0000	Business and Financial Operations Occupations	37,202	19,491	56,694	3.4%
15-0000	Computer and Mathematical Occupations	16,424	0	16,424	1.0%
17-0000	Architecture and Engineering Occupations	83,005	3,898	86,903	5.2%
19-0000	Life, Physical, and Social Science Occupations	1,309	0	1,309	0.1%
21-0000	Community and Social Service Occupations	0	0	0	0.0%
23-0000	Legal Occupations	242	0	242	0.0%
25-0000	Education, Training, and Library Occupations	17	0	17	0.0%
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	1,099	0	1,099	0.1%
29-0000	Healthcare Practitioners and Technical Occupations	293	0	293	0.0%
31-0000	Healthcare Support Occupations	0	0	0	0.0%
33-0000	Protective Service Occupations	335	0	335	0.0%
35-0000	Food Preparation and Serving Related Occupations	199	0	199	0.0%
37-0000	Building and Grounds Cleaning and Maintenance Occupations	5,267	58,474	63,740	3.8%
39-0000	Personal Care and Service Occupations	0	0	0	0.0%
41-0000	Sales and Related Occupations	28,931	38,982	67,913	4.1%
43-0000	Office and Administrative Support Occupations	116,270	38,982	155,253	9.3%
45-0000	Farming, Fishing, and Forestry Occupations	552	0	552	0.0%
47-0000	Construction and Extraction Occupations	272,939	0	272,939	16.4%
49-0000	Installation, Maintenance, and Repair Occupations	111,072	194,912	305,984	18.4%
51-0000	Production Occupations	451,024	0	451,024	27.0%
53-0000	Transportation and Material Moving Occupations	81,977	15,593	97,570	5.9%

Note: Occupational definitions as per the BLS's Standard Occupational Classification (SOC) system
Forecasts are derived using the DBCCA Electricity Power Forecasts, the WPK model and related
research on occupational breakdowns for the RE, EE, gas, coal, nuclear and related power supply sectors

Wind: in the case of wind, as with solar, we can get total employment data for the sector via industry surveys and some generalized breakdown of employment types, but nothing more specific than that. Again, we have decided here to use the PERI approach, where they estimated the sub-industries that would make up wind:

- Construction - 26%
- Plastic products – 12%
- Fabricated metal – 12%
- Machinery – 37%
- Mechanical power transmission equipment - 3%
- Electronic components – 3%
- Scientific and technical services – 7%

Using this framework yields the following occupational employment outcome:

Exhibit 24: Wind Sector Related Occupational Employment Breakdown, Cumulative 2010-2030

BLS SOC code	Occupation Title	CIM - direct	O&M direct	Sum total	% total
00-0000	Industry Total	749,315	403,669	**1,152,984**	
11-0000	Management Occupations	50,796	20,183	70,979	6.2%
13-0000	Business and Financial Operations Occupations	26,619	20,183	46,802	4.1%
15-0000	Computer and Mathematical Occupations	11,480	0	11,480	1.0%
17-0000	Architecture and Engineering Occupations	54,365	4,037	58,402	5.1%
19-0000	Life, Physical, and Social Science Occupations	0	0	0	0.0%
21-0000	Community and Social Service Occupations	0	0	0	0.0%
23-0000	Legal Occupations	297	0	297	0.0%
25-0000	Education, Training, and Library Occupations	8	0	8	0.0%
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	0	0	0	0.0%
29-0000	Healthcare Practitioners and Technical Occupations	0	0	0	0.0%
31-0000	Healthcare Support Occupations	0	0	0	0.0%
33-0000	Protective Service Occupations	392	0	392	0.0%
35-0000	Food Preparation and Serving Related Occupations	58	0	58	0.0%
37-0000	Building and Grounds Cleaning and Maintenance Occupations	3,685	60,550	64,235	5.6%
39-0000	Personal Care and Service Occupations	0	0	0	0.0%
41-0000	Sales and Related Occupations	24,454	40,367	64,821	5.6%
43-0000	Office and Administrative Support Occupations	78,233	40,367	118,600	10.3%
45-0000	Farming, Fishing, and Forestry Occupations	55	0	55	0.0%
47-0000	Construction and Extraction Occupations	130,021	0	130,021	11.3%
49-0000	Installation, Maintenance, and Repair Occupations	53,074	201,835	254,909	22.1%
51-0000	Production Occupations	274,583	0	274,583	23.8%
53-0000	Transportation and Material Moving Occupations	41,194	16,147	57,340	5.0%

Note: Occupational definitions as per the BLS's Standard Occupational Classification (SOC) system
Forecasts are derived using the DBCCA Electricity Power Forecasts, the WPK model and related
research on occupational breakdowns for the RE, EE, gas, coal, nuclear and related power supply sectors

Coal: here we also face a lack of accurate data with regards to the composition of employment in the coal power supply sector. This is composed of coal mining (the fuel source), transportation (getting the coal to the power stations, then operations and maintenance at the respective coal-powered generators. Since there is no "coal power supply sector" in existence in the data collected by the BLS, we have used the PERI approach to construct a synthetic sector. The weightings are base upon REPP (Renewable Energy Policy Project) research

- Coal mining - 46.4%
- Coal transportation - 29.8%
- Coal power plant operation & maintenance - 23.8%

For the direct CIM jobs associated with new coal CCS investments in our forecasts we have assumed the occupational breakdown follows the BLS's Utilities System Construction sector.

The resulting occupational breakdowns are as follows:

Exhibit 25: Coal Sector Related Occupational Employment Breakdown, Cumulative 2010-2030

BLS SOC code	Occupation Title	CIM - direct	O&M - direct	Total	% total
00-0000	Industry Total	**40,960**	**(578,208)**	**(537,248)**	
11-0000	Management Occupations	2,073	(30,026)	(27,954)	5.2%
13-0000	Business and Financial Operations Occupations	871	(28,783)	(27,912)	5.2%
15-0000	Computer and Mathematical Occupations	54	(10,896)	(10,842)	2.0%
17-0000	Architecture and Engineering Occupations	603	(38,796)	(38,193)	7.1%
19-0000	Life, Physical, and Social Science Occupations	0	(6,528)	(6,528)	1.2%
21-0000	Community and Social Service Occupations	0	0	0	0.0%
23-0000	Legal Occupations	7	(1,134)	(1,126)	0.2%
25-0000	Education, Training, and Library Occupations	0	(67)	(67)	0.0%
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	5	(1,449)	(1,443)	0.3%
29-0000	Healthcare Practitioners and Technical Occupations	39	(1,603)	(1,564)	0.3%
31-0000	Healthcare Support Occupations	0	0	0	0.0%
33-0000	Protective Service Occupations	80	(4,655)	(4,575)	0.9%
35-0000	Food Preparation and Serving Related Occupations	0	(273)	(273)	0.1%
37-0000	Building and Grounds Cleaning and Maintenance Occupations	228	(2,757)	(2,529)	0.5%
39-0000	Personal Care and Service Occupations	0	(213)	(213)	0.0%
41-0000	Sales and Related Occupations	259	(4,730)	(4,471)	0.8%
43-0000	Office and Administrative Support Occupations	3,139	(63,568)	(60,429)	11.2%
45-0000	Farming, Fishing, and Forestry Occupations	0	0	0	0.0%
47-0000	Construction and Extraction Occupations	22,612	(81,510)	(58,898)	11.0%
49-0000	Installation, Maintenance, and Repair Occupations	7,439	(134,855)	(127,417)	23.7%
51-0000	Production Occupations	1,363	(60,203)	(58,839)	11.0%
53-0000	Transportation and Material Moving Occupations	2,162	(105,862)	(103,700)	19.3%

Note: Occupational definitions as per the BLS's Standard Occupational Classification (SOC) system
Forecasts are derived using the DBCCA Electricity Power Forecasts, the WPK model and related research on occupational breakdowns for the RE, EE, gas, coal, nuclear and related power supply sectors

Gas: as per coal, in the absence of readily available data (industry or official), that details the occupational breakdown of the gas power supply sector (construction, fuel supply, operations and maintenance), we are again required to construct a synthetic gas sector, reflecting the inputs that make up gas power generation. The inputs here are:

- Utility System Construction – 100%
- Oil and Gas Extraction – 25.0%
- Pipeline Transportation of Natural Gas – 9.0%
- Natural Gas Distribution – 14.8%
- Electric Power Generation – 51.2%

Using these components, we get the following occupational employment breakdown:

Exhibit 26: Gas Sector Related Occupational Employment Breakdown, Cumulative 2010-2030

BLS SOC code	Occupation Title	CIM - direct	O&M - direct	Total	% total
00-0000	Industry Total	82,008	754,260	**836,268**	
11-0000	Management Occupations	4,150	57,916	62,066	7.4%
13-0000	Business and Financial Operations Occupations	1,743	63,745	65,488	7.8%
15-0000	Computer and Mathematical Occupations	108	22,338	22,446	2.7%
17-0000	Architecture and Engineering Occupations	1,207	87,482	88,689	10.6%
19-0000	Life, Physical, and Social Science Occupations	0	21,789	21,789	2.6%
21-0000	Community and Social Service Occupations	0	0	0	0.0%
23-0000	Legal Occupations	15	4,018	4,033	0.5%
25-0000	Education, Training, and Library Occupations	0	78	78	0.0%
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	11	0	11	0.0%
29-0000	Healthcare Practitioners and Technical Occupations	79	2,485	2,563	0.3%
31-0000	Healthcare Support Occupations	0	0	0	0.0%
33-0000	Protective Service Occupations	159	4,834	4,994	0.6%
35-0000	Food Preparation and Serving Related Occupations	0	0	0	0.0%
37-0000	Building and Grounds Cleaning and Maintenance Occupations	457	3,057	3,514	0.4%
39-0000	Personal Care and Service Occupations	0	0	0	0.0%
41-0000	Sales and Related Occupations	519	13,837	14,356	1.7%
43-0000	Office and Administrative Support Occupations	6,284	99,067	105,350	12.6%
45-0000	Farming, Fishing, and Forestry Occupations	0	0	0	0.0%
47-0000	Construction and Extraction Occupations	45,273	70,304	115,577	13.8%
49-0000	Installation, Maintenance, and Repair Occupations	14,893	164,254	179,147	21.4%
51-0000	Production Occupations	2,729	101,851	104,580	12.5%
53-0000	Transportation and Material Moving Occupations	4,328	36,271	40,600	4.9%

Note: Occupational classifications as as per the BLS's Standard Occupational Classification system
Forecasts are derived using the DBCCA Electricity Power Forecasts, the WPK model and related
research on occupational breakdowns for the RE, EE, gas, coal, nuclear and related power supply sectors

Nuclear: we used the BLS's Utility System Construction and Electric Power Generation, Transmission and Distribution sector occupational data to estimate the CIM and O&M occupational breakdown:

Exhibit 27: Nuclear Sector Related Occupational Employment Breakdown, Cumulative 2010-2030

BLS SOC code	Occupation Title	CIM - direct	O&M - direct	Total	% total
00-0000	Industry Total	107,008	32,911	**139,919**	
11-0000	Management Occupations	5,414	2,093	7,508	5.4%
13-0000	Business and Financial Operations Occupations	2,275	2,366	4,641	3.3%
15-0000	Computer and Mathematical Occupations	141	933	1,074	0.8%
17-0000	Architecture and Engineering Occupations	1,576	3,500	5,076	3.6%
19-0000	Life, Physical, and Social Science Occupations	0	637	637	0.5%
21-0000	Community and Social Service Occupations	0	0	0	0.0%
23-0000	Legal Occupations	19	90	109	0.1%
25-0000	Education, Training, and Library Occupations	0	7	7	0.0%
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	14	137	151	0.1%
29-0000	Healthcare Practitioners and Technical Occupations	103	109	212	0.2%
31-0000	Healthcare Support Occupations	0	0	0	0.0%
33-0000	Protective Service Occupations	208	355	563	0.4%
35-0000	Food Preparation and Serving Related Occupations	0	0	0	0.0%
37-0000	Building and Grounds Cleaning and Maintenance Occupations	596	227	824	0.6%
39-0000	Personal Care and Service Occupations	0	0	0	0.0%
41-0000	Sales and Related Occupations	677	433	1,110	0.8%
43-0000	Office and Administrative Support Occupations	8,199	5,591	13,790	9.9%
45-0000	Farming, Fishing, and Forestry Occupations	0	0	0	0.0%
47-0000	Construction and Extraction Occupations	59,074	1,282	60,356	43.1%
49-0000	Installation, Maintenance, and Repair Occupations	19,433	9,863	29,297	20.9%
51-0000	Production Occupations	3,562	4,736	8,297	5.9%
53-0000	Transportation and Material Moving Occupations	5,647	544	6,192	4.4%

Note: Occupational definitions as per the BLS's Standard Occupational Classification (SOC) system
Forecasts are derived using the DBCCA Electricity Power Forecasts, the WPK model and related research on occupational breakdowns for the RE, EE, gas, coal, nuclear and related power supply sectors

Gas Pipeline and Power Transmission Lines: we used the BLS's Utility System Construction and Electric Power Generation, Transmission and Distribution sector occupational data to estimate the CIM and O&M occupational breakdown:

Exhibit 28: Gas & Power Infrastructure Occupational Employment Breakdown, Cumulative 2010-2030

BLS SOC code	Occupation Title	CIM - direct	O&M - direct	Total	% total
00-0000	Industry Total	363,000	43,052	**406,052**	
11-0000	Management Occupations	18,367	2,738	21,106	5.2%
13-0000	Business and Financial Operations Occupations	7,716	3,095	10,811	2.7%
15-0000	Computer and Mathematical Occupations	480	1,220	1,700	0.4%
17-0000	Architecture and Engineering Occupations	5,345	4,579	9,923	2.4%
19-0000	Life, Physical, and Social Science Occupations	0	834	834	0.2%
21-0000	Community and Social Service Occupations	0	0	0	0.0%
23-0000	Legal Occupations	66	118	183	0.0%
25-0000	Education, Training, and Library Occupations	0	9	9	0.0%
27-0000	Arts, Design, Entertainment, Sports, and Media Occupations	47	180	227	0.1%
29-0000	Healthcare Practitioners and Technical Occupations	348	143	491	0.1%
31-0000	Healthcare Support Occupations	0	0	0	0.0%
33-0000	Protective Service Occupations	706	465	1,170	0.3%
35-0000	Food Preparation and Serving Related Occupations	0	0	0	0.0%
37-0000	Building and Grounds Cleaning and Maintenance Occupations	2,023	297	2,320	0.6%
39-0000	Personal Care and Service Occupations	0	0	0	0.0%
41-0000	Sales and Related Occupations	2,296	567	2,863	0.7%
43-0000	Office and Administrative Support Occupations	27,815	7,314	35,128	8.7%
45-0000	Farming, Fishing, and Forestry Occupations	0	0	0	0.0%
47-0000	Construction and Extraction Occupations	200,645	1,677	202,322	49.8%
49-0000	Installation, Maintenance, and Repair Occupations	65,923	19,097	85,020	20.9%
51-0000	Production Occupations	12,082	500	12,582	3.1%
53-0000	Transportation and Material Moving Occupations	19,140	712	19,852	4.9%

Note: Occupational definitions as per the BLS's Standard Occupational Classification (SOC) system
Forecasts are derived using the DBCCA Electricity Power Forecasts, the WPK model and related research on occupational breakdowns for the RE, EE, gas, coal, nuclear and related power supply sectors

How do the DBCCA Forecast Jobs Numbers Compare to Other Surveys?

It is informative to also look at the DBCCA job forecasts and how they compare to work done by others – what are the similarities and differences. How have other people presented their numbers?

Although the presentation of numbers varies by report, and definitions are sometimes not made clear in the text, almost half of the reports we reviewed used the **jobs-years** definition for their estimates. The balance of the reports detailed either a snapshot of current employment in an energy supply sector/industry or forecast the number of new jobs created at the end of the forecast period.

The table below summarizes these reports, detailing the conclusion and methodology used.

Comparing the jobs estimates outcomes is not easy as the reports differ markedly in terms of their forecast timeframe and sectors they cover. Job creation is forecast between 5,000 and 8 million job-years, depending on whether the report is looking at a single State based initiative or a national program. Some assume permanent changes in energy supply mix, EE initiatives, others assume a one-time spending initiative to foster greater use of RE, EE, or switch from fossil fuels to cleaner alternatives. Few reports have tried to do what we have, to include in one national forecast a mix of RE power sources, a coal-to-gas switch, EE initiatives and required infrastructure build-outs in terms of new gas pipelines and transmission grids.

For the novice reader, it is easy to get confused by some of the headline summary numbers and conclusions. Here are some examples:

"8 million jobs by 2013": That may well seem impressive, but not if you then read on and realize that the quoted 8 million figure is based upon a 2009-2013 timeframe and that the baseline figure of 2.4 million is based on a 2000-2009 timeframe. So, are the 8 million figure cumulative jobs over 14 years? The modeling methodology used in this report suggests 8 million jobs years, but this is not clearly spelt out to the report's reader.

"Installing 300 MW of solar capacity will create 5,000 jobs over 5 years": But then read on and you learn that the ongoing direct O&M employment is just 39 jobs per annum. The headline number is all about the CIM phase of the project with little focus on the jobs that last year after year.

So, although the correct way to report jobs estimate in our opinion is jobs-years (and cumulative job-years when referring to a forecast timeframe), and that is the methodology being used by many of the established researchers in this area, not everyone is yet doing this and even those who do estimate jobs-years in their reports may not clearly specify this in their headline summaries. One reason for this may well be that not everyone understands the job-years concept and the word "jobs" is easier to replace it with. Alternatively, some reports may well be targeting an audience with the goal of possibly grabbing attention from a high jobs estimate.

Our recommendation is to always read the fine-print: are they job-years, are they CIM vs. O&M jobs, how many are direct, indirect or induced, and how many last after the program initiative has been implemented.

Below is a summary from 24 reports that looked at U.S. green jobs, with primarily a focus upon RE and EE initiatives.

Study	Author	Year	Approach	Forecast	Comment
Geothermal Industry Employment: Survey Results and Analysis	GEA - Cédric Nathanaël Hance for DEA Geothermal Program	2005	Survey of 242 companies (60% response rate)	***34,115 new jobs***	Job-years and jobs Sector focus: RE Timeframe: snapshot
Green Recovery	PERI / Center for American Progress	2008	IMPLAN input-output model with enhancements	***2 million jobs***	Job-years Sector focus: RE, EE and transport Timeframe: not given
Current and Potential Green Jobs in the U.S. Economy	Global Insight for the U.S. Conference of Mayors and the Mayors Climate Protection Centre	2008	Hybrid combination, using Input-output model, jobs per MW newly installed capacity and 2:1 ratio for indirect employment.	***4.2 million jobs***	Jobs. Sector focus: RE, EE and transport Timeframe: 2008-2038
Green Technology and the Green Economy	California Economic Strategy Panel / Collaborative Economics	2008	Uses the National Establishments Time-Series (NETS) database based on Dun & Bradstreet business-unit data to estimate employment at businesses identified as working in the green economy	***43,476 people***	Jobs Sector focus: Timeframe: snapshot
20% Wind by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply	U.S. Department of Energy	2008	Uses the NREL JEDI wind power model	***6.2 million jobs***	Job-years Sector focus: RE Timeframe: 2008-2030
How Infrastructure Investments Support the U.S. Economy: Employment, Productivity and Growth	PERI - Political Economy Research Institute at the University of Massachusetts and AAM	2009	IMPLAN input-output model with enhancements	***11,000 new jobs per $1bn invested in energy related infrastructure***	Jobs Sector focus: energy related infrastructure Timeframe: years
US Green Building Council – Green Jobs Study	Booz Allen Hamilton	2009	IMPLAN input-output model with enhancements	***8 million jobs***	Reads as job-years, but a little ambiguous Sector focus: EE Timeframe: 2009-2013
Green Prosperity	PERI - Political Economy Research Institute at the University of Massachusetts	2009	Minnesota IMPLAN Group (MIG) input-output model with enhancements	***1.7 million net new jobs***	Job-years Sector focus: RE, EE and pollution control Timeframe: not given
Unlocking Energy Efficiency in the U.S. Economy	McKinsey & Co	2009	Cites various author estimates for employment creation, using the BEA input/output model.	***500,000-750,000 jobs***	Jobs Sector focus: EE Timeframe: 2009-2020
The Economic Benefits of Investing in Clean Energy	PERI / Center for American Progress	2009	IMPLAN input-output model with enhancements	***2.5 million new jobs***	Job-years Sector focus: RE Timeframe: 10 years
Job Creation Opportunities in Hydro	Navigant Consulting for the National Hydropower Association (NHA)	2010	BEA input-output analysis with industry data (20 companies)	***1.4 million jobs***	Job-years Sector focus: Hydro Timeframe: 2009-2025

Study	Author	Year	Approach	Forecast	Comment
California's Green Economy – Summary of Survey Results	State of California, Economic Development Department	2010	Survey of 43,206 establishments with 35.1% response rate	***432,840 jobs***	Jobs Sector focus: RE and green Timeframe: snapshot
The Solar Year in Review - 2009	SEIA – Solar Energy Industries Association	2010		***46,000 jobs***	Jobs Sector focus: RE Timeframe: snapshot
Energy Efficiency Services Sector: Workforce Size and Expectations for Growth	Charles Goldman, Merrian C. Fuller and Elizabeth Stuart Lawrence Berkeley National Laboratory	2010	Surveys and data analysis for forecasts	***384,000 job-years by 2020***	Jobs years Sector focus: EE Timeframe: 2008-2020
Shining Bright – Growing Solar Jobs in Iowa	The Iowa Policy Project	2011	Input-output model for Iowa with NREL data on costs	***5,000 new jobs***	Job-years Sector focus: RE Timeframe: 5 years
The Solar & Wind Energy Chain in Michigan	Environmental Law & Policy Center	2011	Industry survey	***4,000 wind and 6,300 solar related jobs***	Jobs Sector focus: RE Timeframe: snapshot
Energy Efficiency Investments as a Economic Productivity Strategy for Texas	John A Laitner, American Council for an Energy Efficient Economy (ACEEE)	2011	Proprietary DEEPER – econometric input-output model plus IMPLAN model datasets for Texas	***100,000 jobs***	Jobs Sector focus: EE Timeframe: 2010-2030
New Jobs – Cleaner Air	CERES / PERI	2011	IMPLAN input-output model with enhancements	***1.5 million new jobs***	Job-years Sector focus: RE and pollution control Timeframe: 5 years
Bio-Energy Industries - California	COECCC - Centre of Excellence – Economic and Workforce Development – California Community Colleges	2011	Survey of 350 companies with 70.1% responding	***3,045 jobs***	Jobs Sector focus: RE Timeframe: snapshot
Appliance and Equipment Efficiency Standards – a money maker and job creator	AECCC – Gold, Nadel, Laitner and deLaski	2011	Proprietary DEEPER – econometric input-output model using the IMPLAN input-output data set	***40,000 new jobs***	Jobs Sector focus: EE Timeframe: 2009-2030
Sizing the Green Economy – a national and regional green jobs assessment	Metropolitan Policy Project - The Brookings Institute (and Battelle Technology Partnership Practice)	2011	Uses the National Establishments Time-Series (NETS) database based on Dun & Bradstreet business-unit data to estimate employment at businesses identified as working in the green economy	***2,675,545 jobs***	Jobs Sector focus: RE, EE, pollution reduction and conservation Timeframe: snapshot

Appendix: The BLS Occupational Data and the Cleaner Energy Economy

The BLS collects employment data and reports this on both an industry and occupational basis. The BLS Standard Occupational Classification (SOC) system is used by Federal statistical agencies to classify workers into occupational categories for the purpose of collecting, calculating, or disseminating data. All workers are classified into one of 840 detailed occupations according to their occupational definition.

In terms of industry classifications, the BLS uses the North American Industry Classification System (NAICS). NAICS uses a six-digit hierarchical coding system to classify all economic activity into twenty industry sectors. Five sectors are mainly goods-producing sectors and fifteen are entirely services-producing sectors. This six-digit hierarchical structure allows greater coding flexibility than the four-digit structure of the SIC. NAICS allows for the identification of 1,170 industries.

So, for example, Construction is defined as a NAICS industry and within this industry employment would be reported according to the SOC classification system. From the BLS data one can report the total level of Construction industry employment and then drill down to the occupations of these people (managers, supervisors, laborers, etc.).

At present the BLS does not report employment data on the green economy as distinct subcategories. However, in spring 2011 the BLS did begin two new surveys designed to identify employment related to the green economy.

One survey, the Green Goods & Services Survey (GGS) asks employers to identify if they work in a specific green industry or sector (e.g. solar, wind, etc). Respondents to the survey are then asked to identify how much of their business revenues are green related (%). Based upon this survey, the BLS will be able to report both total and indicative occupational breakdown data for a wide range of green sectors, like RE.

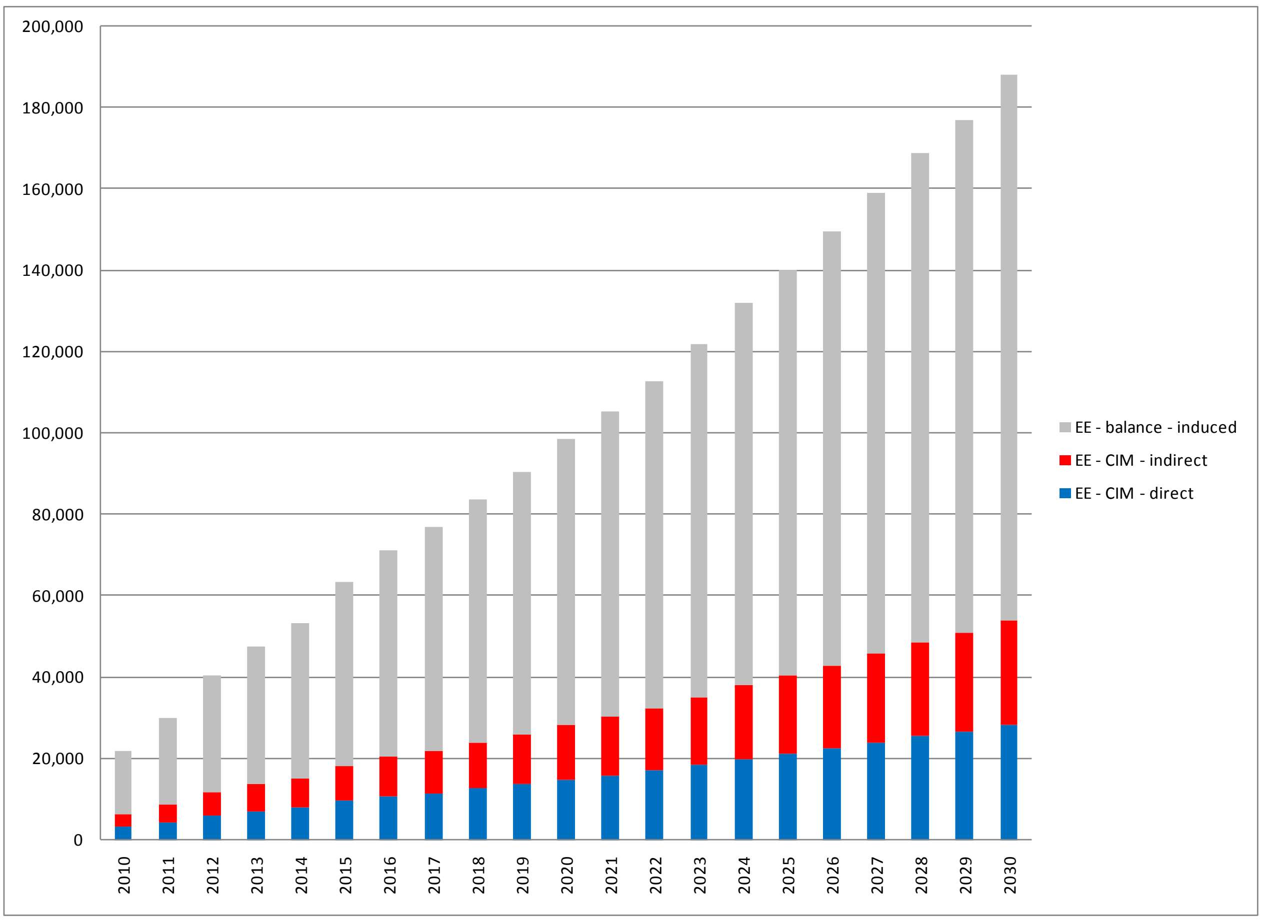
Another new survey will ask businesses to report of how green their business is in terms of what types of green practices they employ. For example, do they use energy efficient lighting control systems, do they re-cycle etc.

The results of both surveys will be published in spring 2012. The GGS will be the most useful in terms of identifying for the first time from the BLS the aggregate level of employment in key RE sectors as well as getting an indication of their occupational make-up.

Appendix: Induced jobs and the impact of energy efficiency savings

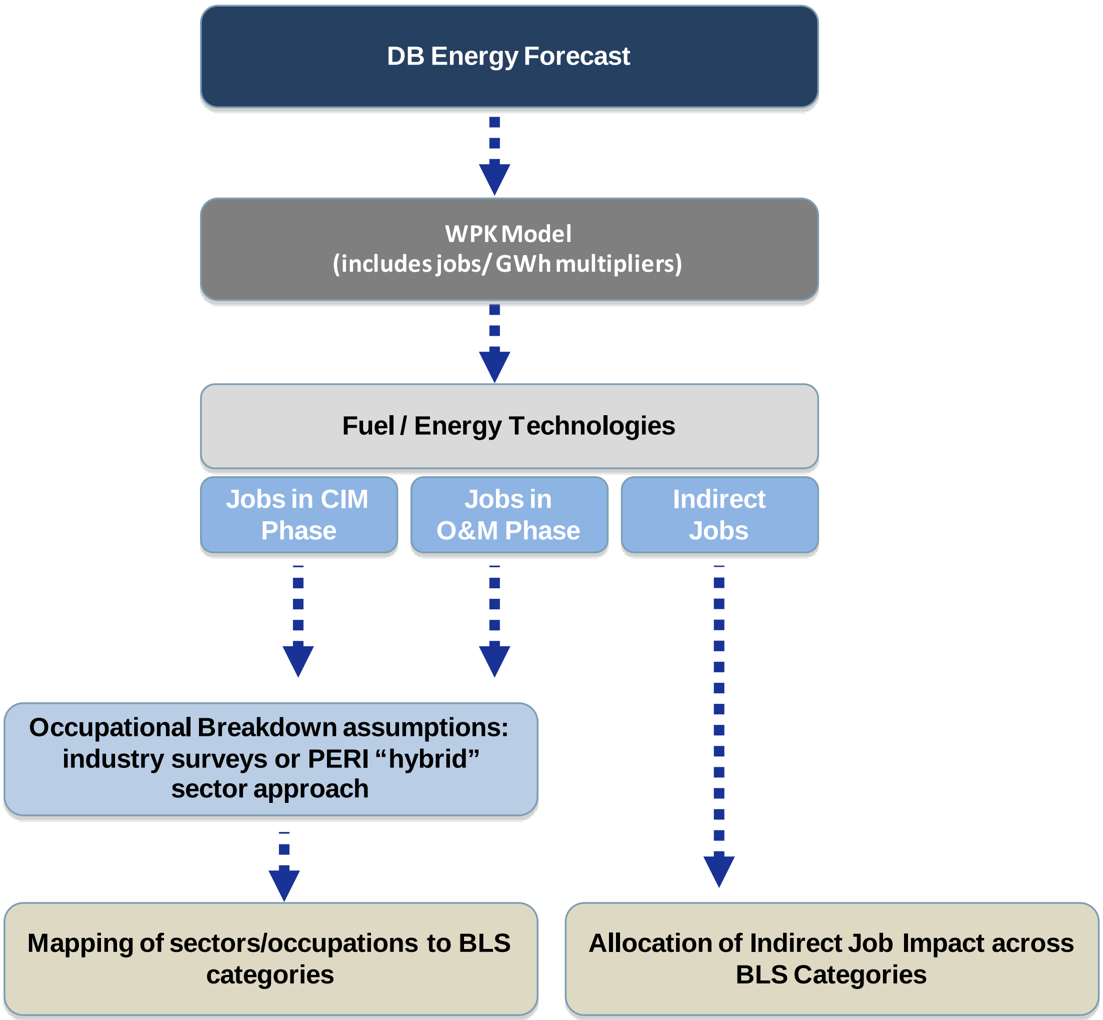
Our forecasts capture both direct and indirect employment impacts, the direct employment being related to the CIM (construction, installation and manufacture) phase of the new power supply facilities, as well as their ongoing O&M (operations, maintenance, and fuel processing) requirements. The indirect employment is an estimate of the supply chain impacts that stem from the CIM phase (jobs that are created by suppliers who are providing the metal that goes into constructing a wind turbine blade). The WPK model also estimates “induced” employment impacts with respect to EE initiatives that are designed to reduce the rate of growth in power demand over the forecast period. That is, reduced energy consumption by households and businesses saves them money which, in turn, allows them to spend more, creating further employment demand in the economy not specifically attributable to the assumed change in energy supply mix. Although the positive effect of induced job creation is shown below, we omitted it from our final results as we did not analyze the potential offsets due to possible higher cost of electricity due to a different energy mix.

Exhibit 29: Annual Net Job Additions for Energy Efficiency – direct, indirect and induced



Appendix: Methodology overview diagram

This flow diagram illustrates the analysis process used in the paper.



Source: WPK Model, DBCCA Analysis.

The DBCCA forecast provides us with a power supply outlook by technology that we input into the WPK model. The WPK model's job multipliers (per GWh) then translate this into job-years forecasts for each power supply sector, for each year in the forecast. We are able to disaggregate the job-years forecasts into those that apply to the CIM phase and those which are relevant to the O&M phase after the new power supply source goes into operation. The indirect jobs multiplier works on each of the respective CIM and O&M job year estimates, yielding indirect CIM and O&M job year forecasts.

The occupational breakdowns are then derived by using industry survey data if available (e.g. Geothermal Energy Association) or from the work done by PERI where an industry survey or related research is not available (e.g. solar or wind). The PERI approach is to look at each power supply sector and define the industries that would be involved in the CIM phase of the new investments. These industries are then assigned weightings (sourced from industry surveys or related research) and combined to create a hybrid sector.

In the case of the PERI approach, we match the industries in each of the defined hybrid sectors to the closest matching industry tracked by the BLS. This then allows one to derive a weighted occupational breakdown of the hybrid power sector. So, whilst the BLS cannot at this time give us an occupational breakdown for the wind, solar, coal power or gas power sectors, with this approach we get a good approximation.

Note, that CIM is a phase and O&M is a phase. As such, the jobs created in the CIM phase when building a power plant will include not only direct laborers, steel workers, concrete pourers, engineers, electricians, plumbers, manufacturing plant employees, but will also involve others who are directly working on the construction, installation or manufacturing phase. This would mean managers and supervisors, administrators, truck drivers etc, all who support the CIM workers. As a result, when looking at the occupational breakdown of the direct CIM phase for wind, we see that there are not only direct jobs created in the areas of construction, installation and production areas, but elsewhere as well reflecting the support jobs that go with this work. The same applies in the O&M phase.

On the indirect jobs mapping by occupation, we reviewed the breakdown of private sector employment in the economy and removed all tertiary occupations that would not be relevant to the CIM or O&M phases and also adjusted for occupations already covered in the CIM and O&M phase. What remains is a weighted occupational profile that we then applied to the aggregate indirect jobs forecast. Although this is not a perfect result, in the absence of a much more complex input-output model, it does provide an intuitively acceptable result that shows the occupational outcome of the indirect jobs forecasts.

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I-024640-1.1