

# Job Growth in Clean Energy

Employment in Alberta's emerging  
renewables and energy efficiency sectors

Binnu Jeyakumar  
November 2016



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# Job Growth in Clean Energy

## Employment potential in Alberta's emerging renewables and energy efficiency sectors

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# Executive summary

Alberta has a meaningful plan to enable the growth of a clean energy industry, with commitment to 30% of electricity generated by renewable sources by 2030, and phasing out pollution from coal-fired generation. A portion of the anticipated revenues from the province's economy-wide carbon levy will be used to enable these efforts. This provides a great opportunity for sustainable employment growth in the clean energy sector. This is in line with the global trends of declining investment and employment in the coal industry, while investment and employment in the renewable sector expands.

The Pembina Institute has conducted an analysis of the employment potential in the renewable energy and energy efficiency sectors in Alberta. Data was collected through literature reviews and from organizations involved in development of projects. The analysis used conservative estimates where there was uncertainty. The results are nevertheless encouraging and paint a positive picture for Albertans.

- In Alberta, investing in renewable sources of electricity and energy efficiency alone would generate more jobs than those lost through the retirement of coal power (Figure 1).
- With a high and sustained pace of renewables growth, there are sustained levels of employment for those engaged in related equipment installations.
- Additional investment in community energy can increase the employment potential by 30-50%.
- Long-term investments in modernizing infrastructure, the grid and our electricity system will result in further job creation with a wide diversity of skills, and in fields that are likely to see sustained growth.

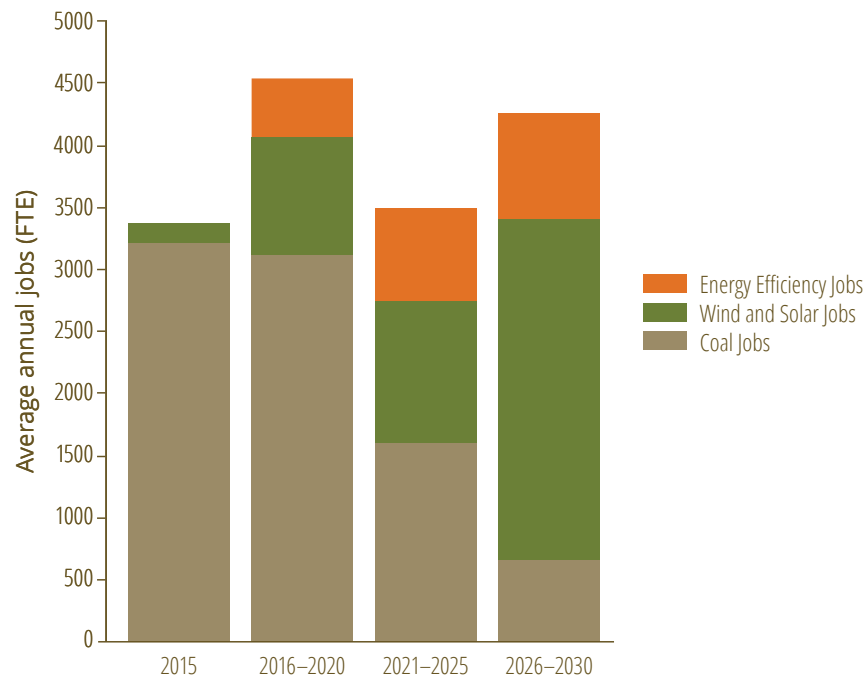


Figure 1. Average annual jobs with coal phase-out, addition of 5,000 MW of renewable energy by 2030, and investment in energy efficiency

To realize these benefits, in addition to the strategies outlined in the Climate Leadership Plan, the province should commit to:

- **Legislated target** — A legislated target<sup>1</sup> for renewables provides certainty to investors and enables adequate planning and support for transition of the workforce, as well as creating sustainable jobs.
- **Enabling greater growth of renewables** — More renewable energy projects result in more jobs as well as more full-time employment of installers. To enable growth of renewables beyond the 5,000 MW procurement target, the government should introduce additional market mechanisms that enable renewables to monetize their full value; for example, allowing renewables to generate credits in the new carbon levy system.<sup>2</sup>
- **Planned schedule for coal power retirement** — To avoid a rapid retirement of coal plants over short periods of time (over 4,000 MW coming offline in 2029),

<sup>1</sup> The government has announced that it will be incorporating the 30% target into a Renewable Electricity Act which will provide the legislative framework for the Renewable Energy Program. Alberta Government, “Renewable electricity plan to create jobs, spur investment,” November 3, 2016. <http://www.alberta.ca/release.cfm?xID=43752ABFE959B-9AD9-9E3C-DBFCF5B5CA13C24C>

<sup>2</sup> At the time of release of this report, the carbon levy program (Carbon Competitiveness Regulation) for the electricity sector was at the design stage and details were not yet finalized.

and to provide certainty for workforce and skills planning, a planned coal plant retirement schedule is needed. This should include an advanced shutdown of certain plants to enable a smooth and well-planned transition for the labour force.

- **Additional small-scale renewables** — Additional community-scale and residential-scale energy generation comes with greater employment but requires specific policies to drive growth. These include a target for additional distributed generation, changes in the rules or tariff structure, and incentive mechanisms.
- **Enabling development of local value chains** — The number of jobs in the sector can be amplified significantly if opportunities upstream in the supply chain are developed locally. A legislated target and the commitment to sustained long-term growth of renewables provide certainty that can enable private sector investment in manufacturing certain components. However, the Energy Diversification Advisory Committee,<sup>3</sup> which has been primarily mandated to recommend value-add opportunities in the oil and gas sector, could also investigate tangible actions the government can take to encourage additional manufacturing capacity within the province.

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<sup>3</sup> Alberta Energy, “Energy Advisory Committee.” <http://www.energy.alberta.ca/Initiatives/4369.asp>



# 1. The move towards a clean economy

Alberta's Climate Leadership Plan has set targets and strategies to enable the growth of the province's clean energy sector. These measures empower the province to play a greater role in an decarbonizing world, rather than simply reacting to socio-economic trends.

Across the globe, coal is under pressure<sup>4</sup> from the falling costs of wind and solar, and increasing stringency in environmental regulatory requirements and climate policies. These pressures are likely to increase. In addition, the current low cost of natural gas is making coal uneconomical in many jurisdictions. As a result of all these factors, jobs in the coal sector are diminishing, while investment in renewables outpaces that in fossil fuels<sup>5</sup> and clean energy jobs are starting to overtake those in the fossil fuel industry.<sup>6</sup>

A key element of Alberta's clean energy efforts, that can help the province position itself appropriately with global trends, is the target to generate 30% of the province's electricity from renewable sources by 2030. This translates to at least 5,000 megawatts (MW) of new renewable capacity. The revenues from the province's carbon levy program<sup>7</sup> will motivate this deployment and support other parts of the clean energy economy. These budgeted funds include \$3.4 billion for large-scale renewable energy, bioenergy and technology, \$2.2 billion for green infrastructure, \$645 million for energy efficiency and community energy initiatives, and \$195 million to assist communities with adjustment.

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<sup>4</sup> Binu Jeyakumar, Bora Plumptre, and Erin Flanagan, *Canada and Coal at COP22: Tracking the global momentum to end coal-fired power – and why Canada should lead the way* (Pembina Institute, 2016), 5. <https://www.pembina.org/pub/canada-and-coal-at-cop22>

<sup>5</sup> Frankfurt School – UNEP Collaborating Centre for Climate & Sustainable Energy Finance, *Global Trends in Renewable Energy Investment 2016*. [http://fs-unep-centre.org/sites/default/files/attachments/uneep\\_gtr\\_data\\_file\\_19\\_april\\_2016.pdf](http://fs-unep-centre.org/sites/default/files/attachments/uneep_gtr_data_file_19_april_2016.pdf)

<sup>6</sup> Anna Hirtenstein, "Clean Energy Jobs Surpass Oil Drilling for First Time in U.S.," *Bloomberg*, May 25, 2016. <http://www.bloomberg.com/news/articles/2016-05-25/clean-energy-jobs-surpass-oil-drilling-for-first-time-in-u-s>

<sup>7</sup> Alberta Government, "Carbon levy and rebates." <http://www.alberta.ca/climate-carbon-pricing.aspx>

These targets and commitments can result in substantial economic development and job creation primarily in:

- Renewable energy generation — utility-scale and residential-scale
- Energy efficiency
- Infrastructure
- Grid modernization — including demand-side management of energy, storage and other elements of a more reliable and resilient grid.

This report focuses on quantifying the employment potential in renewable energy and energy efficiency, and offers a qualitative discussion of the job creation potential of infrastructure and grid modernization. It should be noted that investment in infrastructure and grid modernization will significantly increase the job creation potential of transitioning to a clean energy economy.

## 1.1 Reporting of jobs analysis

Investment in clean energy generates many different types of employment opportunities, through many different channels. In analyzing the jobs potential, three types of jobs are typically considered:

**Direct jobs** — on-site jobs that involve working directly on the project or at the facility. These include designers, developers, managers, construction workers and maintenance teams.

**Indirect jobs** — supporting services and goods needed for the direct jobs. These include activities along the supply chain such as manufacturing and third party equipment procurement.

**Induced jobs** — jobs resulting from the spending of earnings or savings by those directly or indirectly employed or affected by the project. These include jobs at retailers, schools, hospitals and restaurants.

To enable ease of comparison, and to remain conservative in the estimates, this report focuses only on direct jobs. The jobs are expressed in terms of annual full time equivalent (FTE), i.e. a person employed full-time throughout the year.

Some analyses report the job potential in terms of total person-years or job-years over a period of time. This measure reflects the total amount of work created over several years. For example, two full-time jobs that both last 10 years will be reported as 20 job-

years. While total job-years indicate the total amount of work created, the annual FTE reflects the amount of employment in any given year.

## 1.2 Career options in clean economy

The above categorization of direct, indirect and induced jobs does not capture the rich range of career options that is available in the renewable and energy efficiency sectors. The U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy offers a good overview of these options on its website.<sup>8</sup>

Wind facility construction involves a wide range of jobs including construction workers for roads, power lines, trenching, tower erection, foundations and excavations. This includes electricians, backhoe operators, crane operators etc. Project managers, planners, civil and electrical engineers, designers, permitting specialists and environmental specialists are also needed.

Solar installation also engages several different job types including software, power system, electrical and structural engineers, electricians, roofers, IT specialists, project developers, electrical inspectors and permitting specialists.

Operating and maintaining the renewable generation facilities requires field technicians, electricians, mechanics for wind turbines, as well as support staff including accountants, electrical and mechanical engineers, project managers and administrators.

The U.S. Department of Energy also provides career planning tools for wind (see Figure 2) and solar.<sup>9</sup> It shows how different trades and professions can enter and progress in the renewable industry.

Energy efficiency improvements also need a diverse range of professions such as energy auditors, technicians, inspectors, project managers, sales representatives, electricians, retrofit installers, insulators, engineers and analysts.

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<sup>8</sup> U.S. Department of Energy, "Explore Clean Energy Careers," *Office of Energy Efficiency and Renewable Energy*. <http://energy.gov/eere/education/explore-clean-energy-careers>

<sup>9</sup> Interstate Renewable Energy Council and U.S. Department of Energy, "Solar Career Map." <http://irecsolarcareermap.org/>

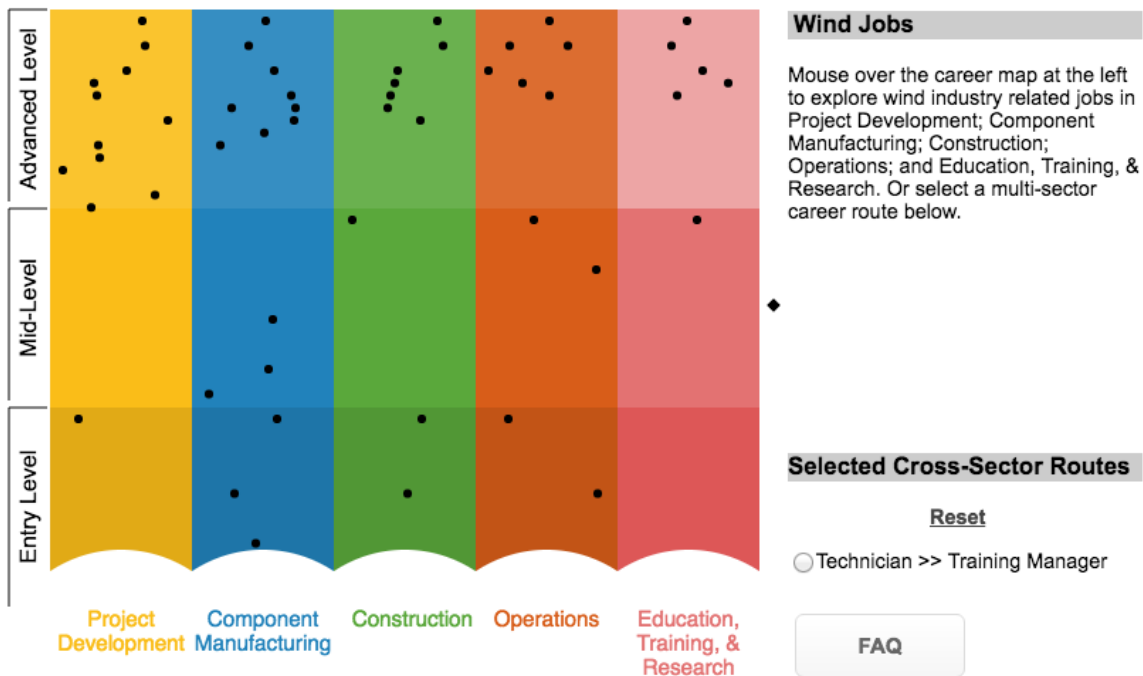


Figure 2. U.S. wind career mapping tool

SOURCE: U.S. Department of Energy<sup>10</sup>

<sup>10</sup> U.S. Department of Energy, “Wind Career Map,” *Office of Energy Efficiency and Renewable Energy*.  
<http://energy.gov/eere/wind/wind-career-map>

## 2. Employment potential for renewables in Alberta

### 2.1 Transitioning workers in the coal industry

Currently, Alberta has 6,267 MW of coal-fired generation.<sup>11</sup> The Climate Leadership Plan mandates an end to pollution from coal plants by 2030. In addition, as stated in Section 1, regulatory and market pressures are making coal generation less economical and will cause the expedited closure of coal plants. This will in turn result in the decline of employment in coal-fired power generation — both at the power plants and in related mining activities — in the province over the next 15 years.

There are approximately 3150 jobs directly related to coal power generation in Alberta.<sup>12</sup> About 80% of these are in coal mining and processing, while the remaining 20% are in the power plants. A clear schedule for the phase-out will enable better support and planning for transitioning workers into other sectors. In addition, as of the time of this report, the default schedule will result in over 4,000 MW of coal capacity coming offline in the year 2029. Advancing the shutdown of some of these plants will result in a smoother transition of the workforce. This report assumes a planned phase-out of coal as shown in Appendix A.3.

### 2.2 Renewable jobs growth

The retirement of coal units creates space for the growth of renewables in the province. The number of the installation jobs, when combined with the operations and maintenance jobs needed for the new renewable facilities – even when estimated conservatively, as in this report – are comparable to the coal jobs of today. The total number of jobs created depends on how fast renewables are ramped up to displace coal.

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<sup>11</sup> Alberta Energy, Electricity Statistics. <http://www.energy.alberta.ca/electricity/682.asp>. Capacity data as of June 2016.

<sup>12</sup> This estimate was calculated using methodology outlined in the appendix, and verified with labour unions. The uncertainty associated with this number is primarily due to the large number of maintenance crews who are brought in for turnarounds, and who have adequate work between the various plants to be primarily employed by the coal sector. Depending on how these crews are accounted for, the number of direct coal jobs can vary.

Figure 3 shows the comparison of renewables jobs gained with the government's commitment to procure 5,000 MW<sup>13</sup> of renewables by 2030 and the coal jobs with coal plants being phased out as per the Alternate Policy Scenario modelled by the Alberta Electric System Operator in its long-term outlook (see Appendix A.3). The actual renewable capacity installed by 2030 can well exceed the 5,000 MW target if renewables are able to monetize their full value, for example, recognizing their emissions reduction potential in Alberta's Carbon Competitiveness Regulation.

Note that a sustained period of renewables growth results in steady employment opportunities in installation of renewables. In addition, having a legislated target for renewables creates certainty that not only attracts investment, but also enables better planning and support for jobs. Job training programs, skills certification and other efforts can be better coordinated with the certainty of a renewables target.

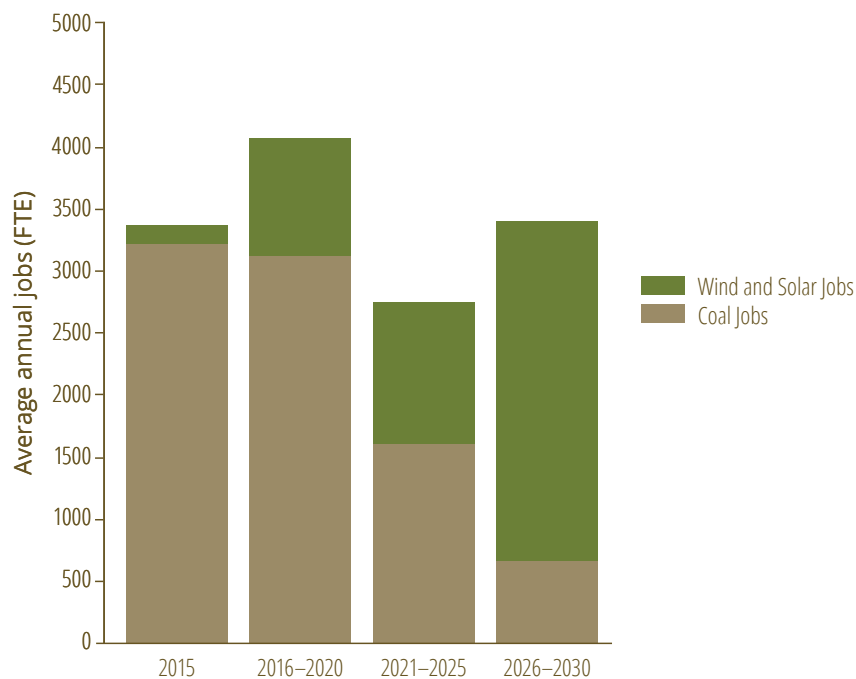


Figure 3. Average annual gains in renewables employment and losses in coal jobs with coal phase-out and 5000 MW of renewables by 2020

The growth in renewable jobs can be further increased with additional community energy projects. With 5,000 MW being procured from utility-scale renewables, and an additional 500 MW procured from community-scale (commercial and residential) solar, there is a 20-30% increase in the renewables jobs generated (see Figure 4.)

<sup>13</sup> In addition to the 5000 MW this scenario also has an extra 200 MW of solar that is not utility-scale.

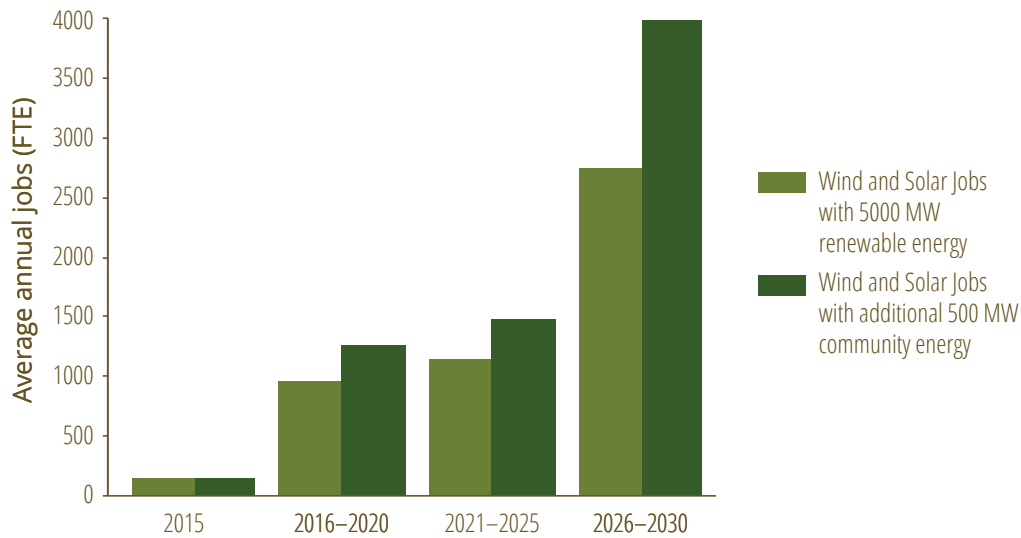


Figure 4. Average annual jobs with additional community renewable energy capacity

In addition to wind and solar jobs, the province can unlock more labour opportunities by incentivizing and supporting the growth of biomass, geothermal and hydroelectric power generation. The anticipated addition of natural gas-fired plants in the grid will also create more jobs in the electricity sector.

The number of jobs in the renewables industry can be further increased by 25%-65% (see job factors in Table 1 in the appendix) by enabling more indirect jobs. This means supporting the development of manufacturing facilities or equipping existing facilities to meet some of the renewable energy sector's supply chain needs. The Energy Diversification Advisory Committee set up by the government could investigate tangible actions to encourage additional manufacturing capacity within the province.

#### Comparison to job estimates by Government of Alberta

The government has estimated that its Renewable Electricity Program will create 7,200 job-years over the life of the program until 2030 (14 years). This is equivalent to approximately 500 FTEs per year, much lower than this report's yearly estimates (900-2500). The primary reason for this discrepancy is that the Pembina Institute model includes solar energy while the government's estimate is understood to be based on extrapolating from Alberta's historic experience with wind. Solar energy creates 10 to 20 times as many jobs as wind for every MW installed. Given the interest already shown by both the solar industry and customers in building new projects in Alberta, we have determined it reasonable to model the contribution of solar to employment in Alberta.

### 3. Employment potential in energy efficiency in Alberta

Investments in energy efficiency programs can generate a significant amount of employment. When added to the renewables job potential, the total more than replaces the jobs lost through the coal phase-out, resulting in net job creation, as shown in Figure 5.

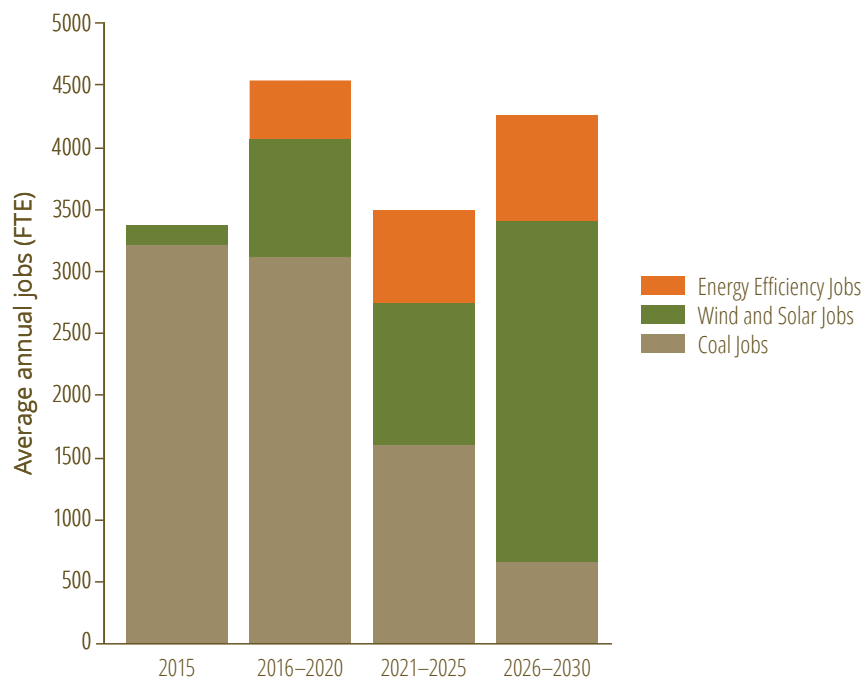


Figure 5. Average annual jobs with coal-fired electricity phase-out, addition of 5,000 MW of renewable energy by 2030, and investment in energy efficiency

As with other industries, the energy efficiency industry benefits greatly with certainty of programs and targets. The long-term sustainability and growth of the industry depends on sustained investment in programs along with leveraging other sources of financing and support for efficiency in the electricity and natural gas sector.



## 4. Employment potential in other clean energy sectors

There are a lot of opportunities for skill development and growth in the workforce beyond renewable energy and energy efficiency. In particular, grid modernization and green infrastructure are two sectors that provide systemic support to renewable energy and energy efficiency, and that have a huge potential for job creation.

As the grid matures, interest in distributed generation grows, and renewables start to penetrate the grid at significant levels, there will be need and opportunity to invest in our electricity system. This includes the addition of storage, processes and technologies to enable more distributed generation; demand-side management; and upgrades to the transmission and distribution system. These emerging areas will need a skilled workforce, which, once developed, might also be sought by other jurisdictions for advice as regions around the world move towards grid modernization. Alberta's leadership in transitioning to a cleaner electricity grid can also make it an attractive and deserving recipient of federal infrastructure investment.

Beyond building-by-building improvements for energy efficiency, there is a huge potential to reduce energy use and emissions by improving the systems around urban and transportation planning. A major part of this effort is investment in public infrastructure. Infrastructure spending is well known to generate employment<sup>14</sup>. There is a unique opportunity here to maximize the efforts from federal, provincial and municipal governments to invest in infrastructure.

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<sup>14</sup> Josh Bivens, *The Short- and Long-Term Impact of Infrastructure Investments on Employment and Economic Activity in the U.S. Economy* (Economic Policy Institute, 2014). <http://www.epi.org/publication/impact-of-infrastructure-investments/>

## 5. Conclusions

Investment in the clean energy sector provides a net benefit to Albertans, not only in terms of their health and mitigating climate change, but also in terms of tangible economic and employment opportunities. Taking a proactive approach will enable a smooth transition to a clean economy. This is a better strategy than continuing to merely react to global forces beyond our control.

The jobs generated through renewable energy and energy efficiency will exceed those lost in the coal industry. This is proving to be the global trend. The job potential can be further enhanced by investing in community energy and, in the long term, in our electricity system and green infrastructure. Governments can help. Announcing a clear schedule for coal power retirement would bolster that certainty and help the new renewables workforce absorb labour gradually. Enacting a legislated target for renewables would create certainty to investors and enable adequate planning and support for workforce transition.

The provincial government can also take further action to ensure Albertans enjoy the benefits of a cleaner energy system. To enable renewables to grow beyond the 5,000 MW procurement target, it can enable additional market mechanisms that allow the full value of renewables to be monetized, allowing them to become more competitive; for example, allowing renewables to generate credits in the new carbon levy system. It can support additional community-scale and residential-scale energy, as this brings high employment. Supportive policies, like a target for additional distributed generation and changes in the rules or tariff structure, could also drive growth. Finally, the number of jobs in the sector can grow significantly if opportunities in the supply chain are developed locally. This means attracting greater manufacturing capacity within the province.

There is a promising future for Alberta's workforce with the transition to a cleaner electricity system. It is possible to address climate change, reduce pollution, and improve employment all together.

# Appendix: Methodology

## A.1 Job factors

There is a wide range of estimates of jobs associated with electricity generation. This is largely due to different assumptions on the size of the project, the degree of maturity of the industry, and the type of direct, indirect or induced jobs that are included in the estimate.

The job factors used in this analysis were based on the sources shown in Table 1, expressed as full-time equivalents per MW (FTE/MW) to indicate the job-years per MW. Job factors are based on many different assumptions around the size of projects, maturity of the industry, geography of the region, and so on, and thus range widely, as illustrated in Figure 6.

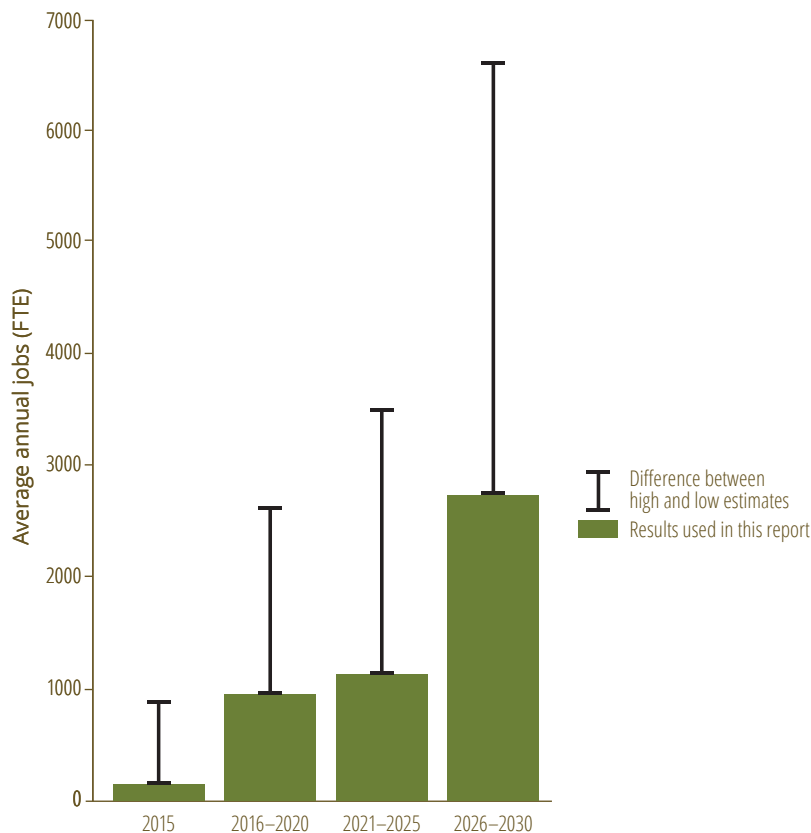


Figure 6. Range of job estimates based on the use of lowest and highest relevant job factors

Table 1. Job factors from various references for electricity generation

Generation Type	Job factor (annual FTE/MW)						
	Used for Pembina Analysis (direct jobs)	Global Literature Review <sup>15</sup> (direct jobs)	Clean Energy Canada <sup>16</sup> (direct jobs)	CanWEA <sup>17</sup> (direct jobs)	CanSIA <sup>18</sup> (direct jobs)	BC Green Jobs <sup>19</sup>	JEDI Model <sup>20</sup>
Wind construction	<b>0.95</b>	2		0.95 (based on conditions in Alberta)		1.83 direct, 8.77 indirect	1 direct, 1.8 indirect (100 MW systems) 20.5 direct, 6.5 indirect (200 kW systems)
Wind O&M	<b>0.1</b>	0.18	0.1	0.1 <sup>21</sup> -0.6		0.18 direct, 0.19 indirect	0.1 direct, 0.03 indirect (100 MW systems) 0.35 direct, 0.05 indirect (200 kW systems)
Solar construction (blended)	<b>12.5</b>	11.2			<b>12.5</b>	15.3	19.0

<sup>15</sup> L. Cameron and B. Zwaan, "Employment factors for wind and solar energy technologies: A literature review," *Renewable and Sustainable Energy Reviews*, 45 (2015). <http://dx.doi.org/10.1016/j.rser.2015.01.001>

<sup>16</sup> Jeremy Moorehouse, *Tracking the Energy Revolution – Canada: Methodology Report* (Clean Energy Canada, 2014). [http://cleanenergycanada.org/trackingtherevolution-global/2015/assets/pdf/MethodologyReport\\_TERGlobal.pdf](http://cleanenergycanada.org/trackingtherevolution-global/2015/assets/pdf/MethodologyReport_TERGlobal.pdf)

<sup>17</sup> CanWEA, *Alberta WindVision Technical Overview Report*, prepared by Solas Energy Consulting (2013). <http://canwea.ca/pdf/Solas-CanWEA-WindVision-29APR2013.pdf>

<sup>18</sup> *CanWEA/CanSIA Submission to the Alberta Climate Change Advisory Panel*, September 30, 2015, 5. The report assumes a ratio of 1:3:6 for residential to commercial to utility-scale.

<sup>19</sup> Pembina Institute, *British Columbia clean energy jobs map – Methodology backgrounder* (2016), 1.

<sup>20</sup> National Renewable Energy Laboratory, "Jobs and Economic Development Impact Models." <http://www.nrel.gov/analysis/jedi/download.html>

<sup>21</sup> Wind turbines with direct drives, instead of gearboxes, are becoming more popular and require less operations and maintenance support. The 0.1 FTE/MW is the O&M jobs estimate for such turbines.

Generation Type	Job factor (annual FTE/MW)						
	Used for Pembina Analysis (direct jobs)	Global Literature Review <sup>15</sup> (direct jobs)	Clean Energy Canada <sup>16</sup> (direct jobs)	CanWEA <sup>17</sup> (direct jobs)	CanSIA <sup>18</sup> (direct jobs)	BC Green Jobs <sup>19</sup>	JEDI Model <sup>20</sup>
Solar O&M (blended)	<b>0.3</b>	0.3	0.2		<b>0.3</b>		0.2
Solar residential construction	<b>20</b>				20 (<30kW)		New: 23.3 direct, 23.3 indirect Retrofit: 20 direct, 20 indirect
Solar Residential O&M	<b>1</b>				1 (<30kW)		0
Solar Commercial-Scale installation	<b>15</b>				15 (30kW – 5MW)		Large commercial: 18.9 direct, 17.6 indirect (1 MW system) Small commercial: 23.2 direct, 21.1 indirect (1 MW system)
Solar Commercial-Scale O&M	<b>0.3</b>				0.3 (30kW – 5MW)		0.2 direct, 0.1 indirect
Solar Utility-Scale installation	<b>10</b>				10 (>15MW)		Fixed: 14.3 direct, 11.9 indirect. With single axis: 17.8 direct and 15.9 indirect
Solar Utility-Scale O&M	<b>0.2</b>				0.2 (>15MW)		0.2 direct, 0.1 indirect
Gas installation	<b>1.7</b>	<b>1.7<sup>22</sup></b>					
Gas O&M	<b>0.08</b>	<b>0.08<sup>23</sup></b>					0.05 direct

<sup>22</sup> B. Heavner and S. Churchill, *Renewables Work: Job Growth from Renewable Energy Development in California* (2002), 5. <http://research.policyarchive.org/5556.pdf>

<sup>23</sup> J. Rutovitz and S. Harris, *Calculating global energy sector jobs: 2012 methodology*. Prepared for Greenpeace International by the Institute for Sustainable Futures (2012), Table 2.

Generation Type	Job factor (annual FTE/MW)						
	Used for Pembina Analysis (direct jobs)	Global Literature Review <sup>15</sup> (direct jobs)	Clean Energy Canada <sup>16</sup> (direct jobs)	CanWEA <sup>17</sup> (direct jobs)	CanSIA <sup>18</sup> (direct jobs)	BC Green Jobs <sup>19</sup>	JEDI Model <sup>20</sup>
Coal O&M	<b>0.1 plants, 0.41<sup>24</sup> mining</b>	0.1 <sup>25</sup>					
Run-of-River Hydro installation	<b>5.76</b>					5.76 direct, 12.78 indirect	
Run-of-River Hydro O&M	<b>0.08</b>		0.75			0.08 direct, 0.11 indirect	
Conventional Hydro Installation	<b>8.87</b>					8.87 direct, 12.78 indirect	17 direct, 3.7 indirect
Conventional Hydro O&M	<b>0.04</b>		0.02			0.04 direct, 0.03 indirect	0.31 direct, 0.09 indirect

<sup>24</sup> Calculated from a coal capacity factor of 78% (average in Alberta from 2006 to 2014) and a job factor of 0.06 job-years/GWh as per Max Wei et al, *Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US?* (2009), 4. [https://rael.berkeley.edu/wp-content/uploads/2015/04/WeiPatadiaKammen\\_CleanEnergyJobs\\_EPolicy2010.pdf](https://rael.berkeley.edu/wp-content/uploads/2015/04/WeiPatadiaKammen_CleanEnergyJobs_EPolicy2010.pdf)

<sup>25</sup> *Calculating global energy sector jobs*, 5.

## A.2 Capacity factors

The jobs generated by a power plant depend largely on the size of the plant, expressed as the maximum rated capacity in MW, or simply capacity. However, the amount of electricity that the plant generates (GWh) depends on how often it is running and at what capacity at any given time. To model this, a capacity factor is used, which is the ratio of the electricity that the plant does produce to the electricity it could produce if it ran continuously all year and at 100% of its maximum rated capacity at all times.

Table 2. Capacity factors by technology type

Generation Type	Capacity factor					
	Used for Pembina Analysis	Clean Energy Canada <sup>26</sup>	CanWEA <sup>27</sup>	CanSIA <sup>28</sup>	NREL <sup>29</sup>	2015 Alberta Statistics <sup>30</sup>
Wind	<b>40% (new), 31% (old)</b>	32.1%	40%			29% (2015), 31% (2010-2014)
Solar	<b>11% (old)<sup>31</sup>, utility: 21%, commercial: 15%, residential: 17%</b>	17%		13-16%	Utility: 14-28% Commercial: 11.4-18.7% Residential: 12.5-20.7%	
Biomass	<b>58%</b>	70%			52%	58%
Hydro	<b>26%</b>	50%	50%			26% (historical average)

<sup>26</sup> *Tracking the Energy Revolution – Canada: Methodology Report*. This report uses global averages from the International Renewable Energy Agency's 2014 Renewable Power Generation Costs report.

<sup>27</sup> *Alberta WindVision Technical Overview Report*.

<sup>28</sup> Canadian Solar Industries Association, *2016 FIT Price Review Submission to the Independent Electricity System Operator* (2015), 14. [http://www.cansia.ca/uploads/7/2/5/1/72513707/cansia\\_submission\\_-\\_2016\\_price\\_review.pdf](http://www.cansia.ca/uploads/7/2/5/1/72513707/cansia_submission_-_2016_price_review.pdf)

<sup>29</sup> National Renewable Energy Laboratories, "2016 Annual Technology Baseline." [http://www.nrel.gov/analysis/data\\_tech\\_baseline.html](http://www.nrel.gov/analysis/data_tech_baseline.html)

<sup>30</sup> Alberta Energy, "Electricity Statistics", generation data as of December 2015, capacity data as of June 2016. <http://www.energy.alberta.ca/electricity/682.asp>

<sup>31</sup> Based on data collected from a sample of solar installers, the average capacity factors of systems installed have been between 9% and 13%.

Generation Type	Capacity factor					
	Used for Pembina Analysis	Clean Energy Canada <sup>26</sup>	CanWEA <sup>27</sup>	CanSIA <sup>28</sup>	NREL <sup>29</sup>	2015 Alberta Statistics <sup>30</sup>
Gas	<b>70%</b> <sup>32</sup>		95% (cogeneration, 20% (combined cycle), 50% (simple cycle))		85% <sup>33</sup>	52% 2016 long-term outlook: combined cycle 50-75%, simple cycle 10-30%
Coal	<b>80%</b>		93%			75% 80% (historical)

## A.3 Generation capacity scenarios

### Coal phase-out schedule

With the Climate Leadership Plan's target of no pollution from coal plants by 2030, it is widely accepted that Alberta will have no coal-fired generation by 2030. The schedule for when each coal plant will come offline is determined by market forces (such as the power price) and by regulations.

**Federal GHG regulations (prior to Alberta's Climate Leadership Plan):** In this schedule, the coal power plants will not operate beyond the end of their life as determined by the federal regulation for coal-fired electricity generation

**Alberta's Climate Leadership Plan (default):** With the new 2030 target, the default plan for Alberta is that all plants that were planned to be decommissioned after 2030 will come offline by the end of 2029. But further mandates from the Alberta government and an extended period of low power prices can advance the shutdown schedule.

<sup>32</sup> Calculated assuming the ratio of cogeneration to combined cycle to simple cycle stays similar to the current generation mix, and using the capacity factor from the CanWEA report. A more accurate calculation of the capacity factor will require detailed modelling of the grid and the electricity market.

<sup>33</sup> National Renewable Energy Laboratories, *Cost and Performance Assumptions for Modeling Electricity Generation Technologies*, prepared by ICF International (2010), 11.  
<http://www.nrel.gov/docs/fy11osti/48595.pdf>



**Pembina coal phase-out:** The Pembina Institute has proposed a shutdown schedule that brings some power plants offline earlier than the timeline dictated by the federal regulations for coal power. This proposal provides several benefits in terms of reduced pollution, avoidance of health costs of up to \$3 billion<sup>34</sup>, and an earlier growth of renewables, as well as the jobs associated with them. The Pembina Institute schedule has been slightly modified for the purpose of this report to show that some of the plants with a proposed end date of 2016 are likely to come offline in 2017 or 2018.

**AESO Alternate Policy Scenario:** In their 2016 Long-term Outlook, the Alberta Electric System Operator published an Alternate Policy Scenario that sees an accelerated growth of renewable energy, and phases out all coal fired generation before year 2030.<sup>35</sup>

The implications of the scenarios for each plant's decommissioning date are summarized in Table 3 below. For the coal calculations in this report — unless explicitly stated otherwise — the AESO scenario was chosen since it has been modelled by a government agency, and has a planned and measured phase-out schedule that avoids a cliff of a large amount of coal capacity coming offline in 2029.

Table 3. Scenarios for schedule of phasing out coal-fired power plants

Facility	Commissioning year	Federal GHG regulation	Modified proposed schedule by Pembina	Alberta Climate Plan default	AESO Alternate Policy Scenario
Battle River 3	1969	2019	2017	2019	<b>2019</b>
Sundance 1	1970	2019	2018	2019	<b>2019</b>
Milner 1	1972	2019	2016	2019	<b>2019</b>
Sundance 2	1973	2019	2018	2019	<b>2019</b>
Battle River 4	1975	2025	2017	2025	<b>2019</b>
Sundance 3	1976	2026	2020	2026	<b>2020</b>
Sundance 4	1977	2027	2020	2027	<b>2020</b>

<sup>34</sup> Pembina Institute, the Asthma Society of Canada, Canadian Association of Physicians for Environment, and the Lung Association, Alberta & NWT, *Breathing in the Benefits* (2016). <https://www.pembina.org/pub/breathing-benefits>

<sup>35</sup> AESO 2016 Long-term Outlook. <https://www.aeso.ca/grid/forecasting/>

Sundance 5	1978	2028	2020	2028	<b>2020</b>
Sundance 6	1980	2029	2020	2029	<b>2020</b>
Battle River 5	1981	2029	2021	2029	<b>2021</b>
Keephills 1	1983	2029	2023	2029	<b>2023</b>
Keephills 2	1983	2029	2023	2029	<b>2024</b>
Sheerness 1	1986	2036	2026	2029	<b>2026</b>
Genesee 2	1989	2039	2029	2029	<b>2028</b>
Sheerness 2	1990	2040	2026	2029	<b>2027</b>
Genesee 1	1994	2044	2029	2029	<b>2026</b>
Genesee 3	2005	2055	2029	2029	<b>2029</b>
Keephills 3	2011	2061	2029	2029	<b>2029</b>

## Renewables ramp-up

The pace and magnitude of renewables growth in Alberta will depend on the effectiveness of the government's incentives and procurement process, and the coal phase-out schedule. Once the amount of renewables in the grid is significant enough to require other supporting elements such as storage, the rate at which these elements are integrated will affect the pace of renewables growth as well.

In addition, there are different scenarios possible with several combinations and ratios of renewable sources of energy. In our analysis, we have modelled a few likely scenarios:

**AESO Alternate Policy Scenario:** This scenario includes an additional 7200 MW of wind, 1000 MW of solar, 330 MW of hydro, as well as a few other sources by 2030. The schedule of ramp-up is modelled as indicated in the AESO Long-term Outlook for the Alternate Policy Scenario. This scenario has not been included in the report, as the announcements from the government at the time of publishing of the report reflect the following scenario more closely.

**5,000 MW Baseline Scenario:** It results in an additional 4,000 MW of wind and 1,000 MW of utility-scale solar built by 2030. An additional 200 MW of non-utility-scale solar is assumed to come online with a ratio of 3:1 between commercial and residential solar. This scenario was developed based on the commitment by the

Government of Alberta to support 5,000 MW of additional renewables.<sup>36</sup> In this scenario two-thirds of the new solar capacity is modelled to come online in the last five years (2026-2030) when the solar market will be much more mature. It is assumed that there is no significant growth in hydro, biomass or geothermal. The corresponding decline in coal is still modelled using the AESO Alternate Policy Scenario, with any differences in needed generation being met by additional gas.

**Additional Community Energy Scenario:** Similar to the baseline scenario above, this results in an additional 4,000 MW of wind and 1,000 MW of utility-scale solar built by 2030. However an additional 700 MW of non-utility-scale solar (500 MW more than the baseline) is assumed to come online with a ratio of 3:1 between commercial and residential solar. As in the baseline scenario, two-thirds of the new solar capacity is modelled to come online in the last five years (2026-2030) when the solar market will be much more mature. It is assumed that there is no significant growth in hydro, biomass or geothermal. The corresponding decline in coal is still modelled using the AESO Alternate Policy Scenario, with any differences in needed generation being met by additional gas.

In modelling the build of new solar capacity – unless otherwise specified – it is assumed that 60% of it is utility-scale, 30% is commercial, and 10% is residential as indicated by CanSIA.<sup>37</sup> We further assume that of the new hydro capacity, 25% is run-of-river and 75% is conventional dammed hydro.

Note that while biomass and geothermal are not modelled, it is very likely that additional capacity in both technologies will be possible by 2030, depending on how fast their markets mature and the level of support provided.

## A.4 Energy efficiency

The jobs generated are modelled to be proportional to the amount invested in efficiency programs. Every million dollars of spending in electrical efficiency programs result in 24 job-years and every million dollars of spending in heating efficiency programs result in

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<sup>36</sup> Alberta Government, “Renewable energy target improves health, environment,” news release, September 14, 2016. <http://www.alberta.ca/release.cfm?xID=434069BDC1E17-D70A-8BEE-63FDAE67F6CC37EA>

<sup>37</sup> *CanWEA/CanSIA Submission to the Alberta Climate Change Advisory Panel*, 5. The assumption is that every 150 MW of solar is made up of 15 MW residential, 45 MW commercial and 90 MW utility-scale.

17 job-years.<sup>38</sup> These numbers include direct jobs as well as indirect and induced jobs created from the savings generated and spent in local economic activity. As a rough approximation, it is assumed that 26% of these jobs are direct jobs as a result of efficiency investment, while 74% are indirect and induced jobs resulting from energy savings.<sup>39</sup> These figures are the net jobs created, taking into account the decrease in jobs due to reduced demand for electricity and natural gas.

The program spending is modelled after the budget for Energy Efficiency Alberta, set to begin operations in 2017. It is assumed that the budget for efficiency programming is split equally between electrical and heating efficiency programs. The resulting schedule of spending and job creation is summarized in Table 4.

Table 4. Energy efficiency program spending and job creation

Year	Efficiency program spending (\$ millions)	Direct jobs	Indirect jobs
2015	-	-	-
2016	-	-	-
2017	34	182	517
2018	68	363	1034
2019	125	666	1896
2020	129	686	1954
2021	133	707	2011
2022	136	727	2069
2023	140	747	2126
2024	144	767	2184
2025	148	787	2241
2026	152	808	2298
2027	155	828	2356

<sup>38</sup> Alberta Energy Efficiency Association, *GHG Savings and Energy Efficiency High-Level Opportunity Analysis in Alberta*, prepared by Dunskey Energy Consulting (2015), 7. <http://www.aeea.ca/pdf/energy-efficiency-scenarios-for-alberta.pdf>

<sup>39</sup> Acadia Center and Environment Northeast, *Energy Efficiency: Engine of Economic Growth in Canada*, prepared for Natural Resources Canada (2014), 20. [http://acadiacenter.org/wp-content/uploads/2014/11/ENEAcadiaCenter\\_EnergyEfficiencyEngineofEconomicGrowthinCanada\\_EN\\_FINAL\\_2014\\_1114.pdf](http://acadiacenter.org/wp-content/uploads/2014/11/ENEAcadiaCenter_EnergyEfficiencyEngineofEconomicGrowthinCanada_EN_FINAL_2014_1114.pdf)

2028	159	848	2413
2029	163	868	2471
2030	167	888	2528

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