Employment Effects of the Energy Transition driven by the carbon dividend and tax plan

Roy Wehrle, December 15, 2019

This Study is a companion piece by Professor Roy Wehrle to the previous proposal authored by Professors Roy Wehrle and Don Wuebbles entitled, A National Energy Transition Plan for America: Informing the Development of a Carbon Dividend Approach of May 31, 2019.

Summary

To forestall the most damaging aspects of climate change, aggressive climate policy must be passed by 2020 or 2021. This Employment Study estimates the overall employment gains and losses that a market-driven carbon tax and dividend policy would create in the U.S. during the decade of the '20s. It concludes that such a climate policy will transform the U.S. economy in a healthy way by generating change that is powered by innovation and new investment, creating new jobs and improved incomes. Economic progress necessarily brings disruptive change – significant progress and overall job creation, but the loss or displacement of existing jobs for some. It is crucial to support workers during this adjustment phase through inclusive policies focused on reinsertion in the job market and job creation in regions affected by job losses. Nevertheless, the often unnoticed employment and income benefits will be quite remarkable. The energy transition based on repricing carbon and rebating taxes as dividends is not only a sure way to reduce carbon emissions rapidly but will also drive major economic growth and employment.

Objective

The objective of this study is to estimate job gains and losses in the economy through 2030 caused by a tax and dividend energy transition that reduces carbon emissions by the United States 50% by 2030. Four different perspectives will be used to estimate the loss or gain in jobs created by a national energy transition:

> **Section A –** looks at foreign governments with operating carbon tax and dividend policies;
> **Section B –** examines how carbon pricing will create and eliminate jobs in the energy sector;
> **Section C** – assesses effects on the rest of the economy; and
> **Section D –** calculates employment estimates of the entire U.S. economy using two computable general equilibrium models, both with and without a national energy transition.

A national energy transition can be carried out either by repricing carbon or through regulations and induced investment. This study emphasizes the former, but the latter is also considered since it too seeks a major reduction in emissions, and both will affect employment.

A. Real World Energy Programs and Experience

Sweden passed one of the first carbon taxes in 1991 with a tax rate equivalent to $30/ton which has gradually increased to $132/ton equivalent today. The plan provided exceptions for manufacturing and other users. Between 1990 and 2017, the Swedish GDP expanded by 78% and emissions decreased by 26%. In addition, unemployment was lower in Sweden than in most European Union countries without such a tax. (Johansson, Bengt 2000; Murphy 2019)

British Columbia, Canada passed a carbon tax and dividend in 2008 and the GDP grew 19% through 2016 while unemployment declined (7.8%/2009, 6.8%/2012 and 4.8%/2018). (British Columbia Carbon Tax, 2019)

Switzerland had similar economic success. (OECD, 2019) (Plummer, 2019)

California's Proposition 39 Climate Policy used investment projects rather than a tax, placing over $1.5 billion in 2,189 energy conversion and efficiency projects from 2014 to 2018 creating 20,000 new jobs. However, there was no way to measure jobs lost, though these were likely small since the projects were largely add-ons to improve efficiency. (Legislative Analyst's Office 2018; Zabin 2018)

In Navarre Province, Spain they also used government investment and regulations to jolt the economy to life in a push to promote sustainable energy. Today, wind and solar provide a remarkable 65% of the provincial energy. (Cook 2011) The Regional Minister, Jose Maria Roig Aldasoroe stated:

> *"In Navarre, the development of renewable energies, and above all wind energy, has created wealth, employment and technological development, and I can assert that this can be achieved in any other region or country. Our region's GDP is among the three highest in Spain…. Now, after the strong economic and employment crisis that affects Spain in particular, Navarre maintains itself as the Spanish region with the least unemployment*."

Countries and provinces which have boldly pushed wind and solar energy through either carbon pricing or regulation and investment have energized their economies, boosting growth, new technology and employment.

B. Employment Estimates within the Energy Sector

There is general agreement that a tax/dividend plan passed by 2020/21 will cause the electric power sector to switch to sustainable fuel by 2030, but the conversion to electric and hydrogen fuels for cars, trucks and busses will still be in a developing stage with the main driver of uptake coming from cheaper and improved batteries (Bloomberg, 2019). Thus, it is assumed that manufacturing employment related to ground transportation will only be getting a good start during the '20s and will be discussed only briefly. This analysis of the power sector emphasizes two main factors: a) the net employment changes caused by moving from fossil to non-fossil fuels, and b) the employment effects in the rest of the economy from both the energy source conversion plus the energy efficiency projects carried out by citizens and others through government assistance. (Climate Leadership Council 2019)

Three steps of analysis in the power sector will be required: a) Explain how carbon pricing will work during the '20s, b) explain how dividends will impact the economy and employment, and c) estimate overall employment impacts within the energy sector during the decade.

1. Electric Power Sector: How a carbon tax will affect employment during the '20s.

Increased price of fossil fuel energy – Consumers will increasingly switch to non-fossil energy as the carbon-boosted price of fossil fuel rises. This will take place in two ways: switching from fossil to sustainable-sourced electric power, (Section B1) and from old fashioned electric home and hot water heating to efficient fuel pumps (Section B4). Both existing and new vendors will rush in to meet this new demand, creating jobs and moving the energy transition forward.

The electric power sector will be the first to transition to sustainable energy because replacements by sustainable sources of energy are already available and declining in cost, namely wind, solar and storage. (IRENA, 2018)

Concurrently, the increasing price differential between non-fossil and fossil fuels will create a profit pull for existing innovating firms to produce both sustainable electric energy and products made with low carbon energy. (Jacobson 2017) The size of the price differential between the two sources of electricity will determine both how fast consumers switch energy sources and how quickly existing and new firms shift to produce sustainable energy sources and storage.

Employment The energy sector is now the only place to make good comparisons between jobs lost and gained in the energy transition because here both energy sources (replacing and replaced) exist today and their job requirements can be measured. Even so, because the various studies make varied assumptions, it is difficult to compare directly. The London School of Economics (Fankhauser, Samuel 2008) describes the Kammen et al piece as "an excellent study." (Kammen 2006). This study looks at employment over the life of the facility and estimates based on other models that solar PV will generate between 7.41 and 10.56 jobs per megawatt and between 0.71 to 2.79 jobs per megawatt for wind compared to about 1 job per megawatt for coal and gas (Wei, M. et al, 2008). In 2017, total clean energy jobs outnumbered coal and gas jobs by nearly 1.5 to 1, with 777,000 jobs (EDF, 2018). Solar and wind sectors have experienced the fastest growth in recent years. Renewable energy projects in the pipelines for 2020 to 2030 for solar PV corresponded to almost 76,000 megawatts – more than double the 2019 installed capacity of 35,000 megawatts (S&P Global 2019). Wind energy projects will increase energy generation by 133,000 megawatts during the same period.

Table 1 - Employment by Energy Source

Energy Technology	Source of Estimate	Average Employment Over Life of Facility (jobs/MWa)		
		Construction, Manufacturing, Installation	O&M and fuel processing	Total Employment
PV 1	REPP, 2001	6.21	1.20	7.41
PV 2	Greenpeace, 2001	5.76	4.80	10.56
Wind 1	REPP, 2001	0.43	0.27	0.71
Wind 2	EWEA/Greenpeace, 2003	2.51	0.27	2.79
Biomass – high estimate	REPP, 2001	0.40	2.44	2.84
Biomass – low estimate	REPP, 2001	0.40	0.38	0.78
Coal	REPP, 2001	0.27	0.74	1.01
Gas	Kammen, from REPP, 2001; CALPIRG, 2003; BLS, 2004	0.25	0.70	0.95

Table 1: Average employment for different energy technologies. "MWa" refers to average installed megawatts de-rated by the capacity factor of the technology; for a 1 MW solar facility operating on average 21% of the time, the power output would be 0.21 MWa.

Source: (Fankhauser 2008; Wei 2008; Kammen 2006)

Conversions to solar and wind will create from two to seven or more jobs for every megawatt of energy produced while displacing only one worker. The authors caution that the higher labor content of solar and wind will decline somewhat in future years as production efficiency is improved and fewer workers

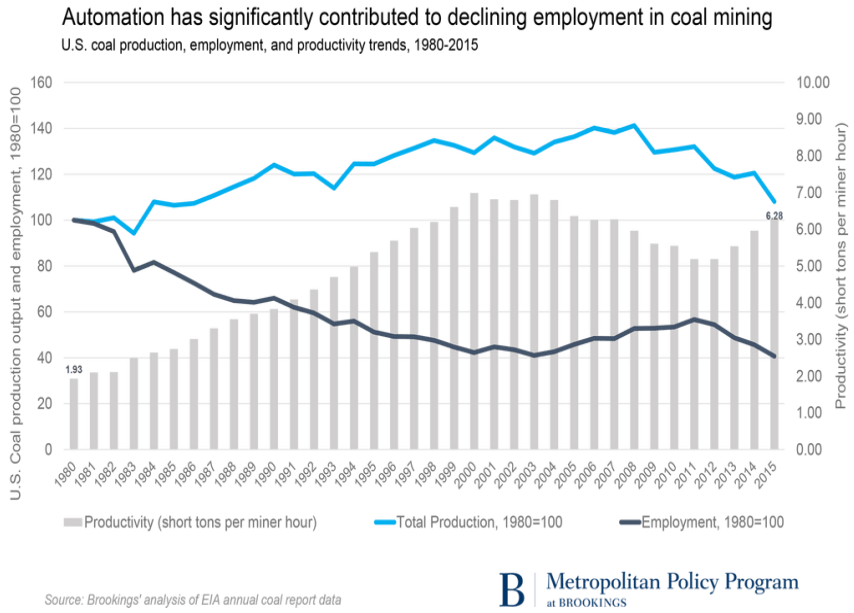
are needed. However, today one can conclude that to attain the current energy consumption through conversion will increase jobs by over two workers for each megawatt converted. The Bureau of Labor Statistics projects that the fastest growing occupations between 2018 to 2028 will be solar PV installers and wind turbine service technicians (BLS, 2019).

So overall, there is no question that transition to wind and solar electricity is a "job creator."

Electric Vehicles To the extent that the demand for electric vehicles takes off, it is not clear now whether this will bring more or less jobs. There will be an increase in employment in producing additional electricity capacity to power electric vehicles, but this increase must be set against the decline in workers needed to produce and maintain electric vehicles because they have fewer moving parts and require fewer mechanics for maintenance. On the other hand, new workers will be required to manufacture batteries. The employment effect of all this is not yet clear even though "More than one-quarter of the jobs in the motor vehicle industry – at least 600,000 – are devoted to making cars cleaner…" today in improving fuel efficiency or making electric vehicles. (Ettenson 2018 page 4)

Coal The energy transition will eliminate the demand for coal**.** The demand is already in decline as it is undercut by the decreasing price of sustainable fuels. Employment has declined sharply due to productivity gains as machines have replaced miners. The transition will cost miners distress, especially in small rural towns where lost jobs are hard to replace. Assistance to unemployed workers in these situations will be essential.

Figure 1 – The Coal Industry* - '80 – 100



* Bars are short tons/miner hour. Light blue is total production; dark is employment.
Source: (Saha D. & S. Liu, 2017)

Figure 1 shows that economic forces including automation have been and will continue to be against employment in coal mines, even if there were no energy transition.

2. Electric Power sector: How dividends boost income, consumption and employment.

In the previous section, the focus was on *price* and how it impacted employment by causing switching of fuel sources. Now attention turns to *income* and how increasing dividend income increases consumption and employment.

First, a detour is necessary to explain how taxes and dividends work together to change consumer incomes and spending. Assume a carbon tax ranging between $25 to $50 per equivalent ton of carbon produced or imported is paid by the energy producer to the IRS. The Treasury places this tax revenue in a Climate Fund and pays the total revenue collected quarterly in equal dividends to all adult citizens.

Energy producers pass on their tax cost to distributors who in turn pass on their portion of the tax to manufacturers and wholesalers down to the retailer. Each seller seeks to recoup the tax they have paid. Individuals all pay a portion of the tax embedded in the price of their product purchases. Around sixty percent of citizens will receive a larger dividend than they pay out in carbon taxes. (NETP, Appendix page 23, End Note 3)

Dividends: Cash and Energy Conservation The reason for discussing the income distribution in detail is to underline an important point relating to disposable income. The poor will spend the extra dividend income received and will cause employment to increase considerably. The individuals with income from the poorest up through those earning middle class incomes receive dividends greater than their carbon taxes paid and hence have cash available left over to spend after paying carbon taxes. Their disposable income will increase. Indeed, the poorest individuals and families pay small carbon taxes and have over half of their dividend left over to spend. Since the poorest people spend nearly all the income they earn, over half of the dividend income will be spent. In short, the dividend approach enables a fairer energy transition, as the poor will not pay for the energy transition but will gain income and employment because of it.

The richest persons in the top 30% of the income distribution have higher tax payments than others because they spend more on carbon-taxed goods. Their taxes exceed their dividends received and constitute the revenues from which all dividends are paid. (see original NETP, page 14, Figure 5) The next lower 10% of individuals (the upper middle class) in the income distribution balance out with taxes roughly equal to dividends received.

Moreover, everyone, regardless of their income, can increase their disposable income by cutting energy expenses and hence carbon taxes through increasing efficiency or by switching to sustainable energy. Both will give them more cash from their dividend to spend. Why? Because they have paid less in carbon taxes. This accelerates the energy transition.

Employment In summary, as the poor and working-class families and individuals push the transition forward, they reward themselves by increasing their disposable income. And as they spend their added income, they increase employment across the economy. Over 60% of the population will receive a big inducement to turn the air conditioner temperature up and the heat controls down, to drive less or switch to a hybrid car, to live without a car in cities, to insulate their homes better, etc. Every dollar they save through conserving energy will come back to them as increased cash to spend from their dividend. For the other 40% of the population, spending less on fossil energy will reduce their carbon taxes. Moreover, the dividends will become larger as the transition proceeds continually boosting spending and

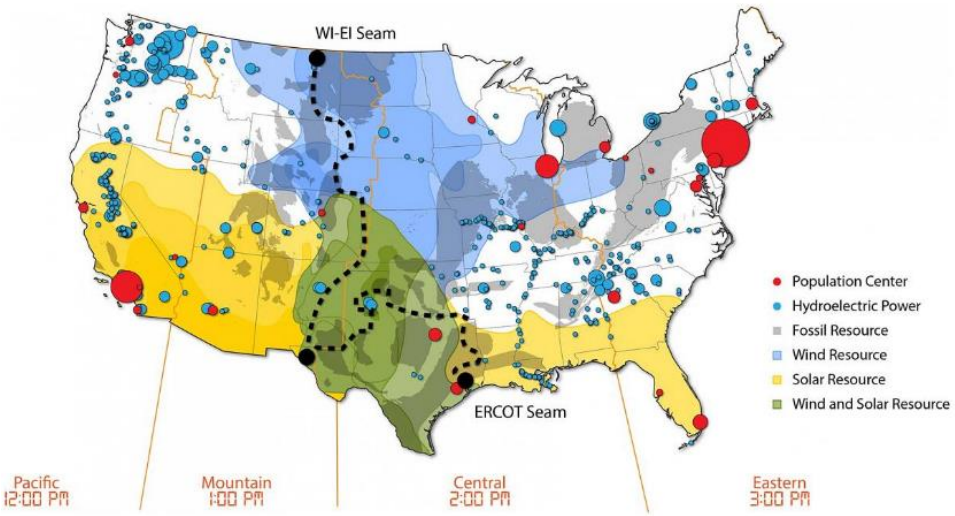
employment. The dividend will decline only as the transition is nearing successful completion and tax revenue falls.

Thus far we have seen projected employment increase through switching to sustainable fuels and conserving energy, while an increase in dividends provides more cash for spending. These both increase employment without displacing any workers.

3. Electric Power Sector: National DC Electric Grids

It is generally recognized that long distance DC power transmission lines will be needed to get solar and wind energy to where it is needed. The full energy transition to sustainable fuels is dependent on increasing solar and wind electricity at a prodigious rate, but also getting it to where it is needed at low cost. Thus, solar surplus energy produced in Arizona and wind surplus from the Dakotas must get to the east and west coast at low cost. Since DC, under certain conditions, carries electricity at low cost over long distances, this may be the best means to achieve national renewable distribution of energy. To be cost effective the high voltage DC long lines must go without interruption from the heavy wind and solar areas to the high demand areas on either coast. In short, it must be an express train. Thus, energy needs along these long lines must be supplied by regional AC suppliers. It is highly likely that construction of a DC national-grid system will be essential. Utilities and merchant transmission developers are likely to develop this (National Renewable Energy Laboratory, 2018). The NREL has investigated upgrading the U.S. electric grid into a more integrated system utilizing renewable energy which would constitute a more reliable and cost-effective power system. Potential designs included HVDC (high voltage direct current) transmission lines. (NREL, 2018)

Figure 2 - Stitching together the major regions of the U.S. power system* could enhance the ability to harness abundant renewable resources and balance loads across the country.



Source: (NREL, 2018)

**This conceptual representation highlights the most prominent renewable energy regions.*

Figure 3 - Pacific DC Intertie

Source: BPA.gov 2010

An example of an operating system is The Pacific DC Intertie, a 3.1 gigawatt HVDC line that stretches 900 miles from the Columbia River in Washington to Los Angles. It provides enough hydropower to meet almost half of the city's peak electricity needs. Another system under development, is the SOO Green Line, which will stretch from Mason City, Iowa to Plano, IL, a hub that can provide 2.1 GW of low-cost, prairie wind to power the Windy City (Gheorghiu 2019). It will have the virtue of being buried underground along railroad tracks in a 2-foot by 5-foot deep trench. The SOO Green Line favors rapid development since it avoids most eminent domain issues while building in exceptional resiliency; underground lines protect power lines from extreme weather outages and transmission losses during extreme heat at the same time they protect the line from domestic sabotage. (Hurlbut, David et al 2017; BPA.gov 2010)

Employment: The building and maintenance of these electric highways will require surveyors, construction workers across the nation, steel mill workers, truck, barge and rail transport, engineers, lawyers, and computer experts and skilled management engineers to create and oversee the continental, smart grid.

4. Electric Power Sector: Assisting Citizens in Switching to Sustainable Energy and Conserving Energy through Improved Efficiency

Thus far, attention has been on how cost efficiencies and dividends affect consumer behavior and the need for constructing a national grid. The energy transition today is greatly assisted by governmental help, mostly at the state level, in finance and assistance to citizens and communities to improve their energy efficiency. The idea is simple. Homeowners, apartment owners, municipalities, mass transit districts, all can save money by improving their energy efficiency and switching to low cost, sustainable energy. Yet, few have the expertise or the extra money to make cost saving investments. Fortunately, the declining cost of sustainable energy today compared to the future rising, tax-boosted, cost of fossil fuel will offer cost savings. The energy sellers can offer cheaper energy by buying at the decreasing sustainable energy price and split the gain with consumers so that both can benefit. (Hubbuch 2019, p3; IRENA 2018) Even more important, energy auditors and consultants can reduce energy bills through conservation measures saving customers money and assisting the energy transition.

Already many states, including California, Illinois, Missouri and Connecticut, have passed legislation to facilitate consumer financing and action. These programs include insulating homes, investing in community wind farm cooperatives, and solar mini smart grids to protect against energy blackouts, as well as installing solar or heat pump systems. Across the country, states, state financed banks (also called Green banks) and community cooperatives are assisting individuals in finding consultants, energy auditors, installers and financing for these energy transition steps.

Jobs gained Table 2 shows the number of jobs created or lost from the energy transition from fossil fuels to renewable energy sources and from energy efficiency jobs. These data show that the number of new jobs created through the energy transition will be considerably greater than the number of jobs that will be lost in oil, natural gas and coal energy production. These statistics confirm earlier estimates in Section B.1 that two or more workers gain employment for every worker who loses her job through solar and wind conversion. Moreover, Table 2 provides valuable estimates of the number of jobs gained through energy construction projects. There will be minimal job losses because most energy conversion and efficiency tasks are "add-ons" rather than replacements.

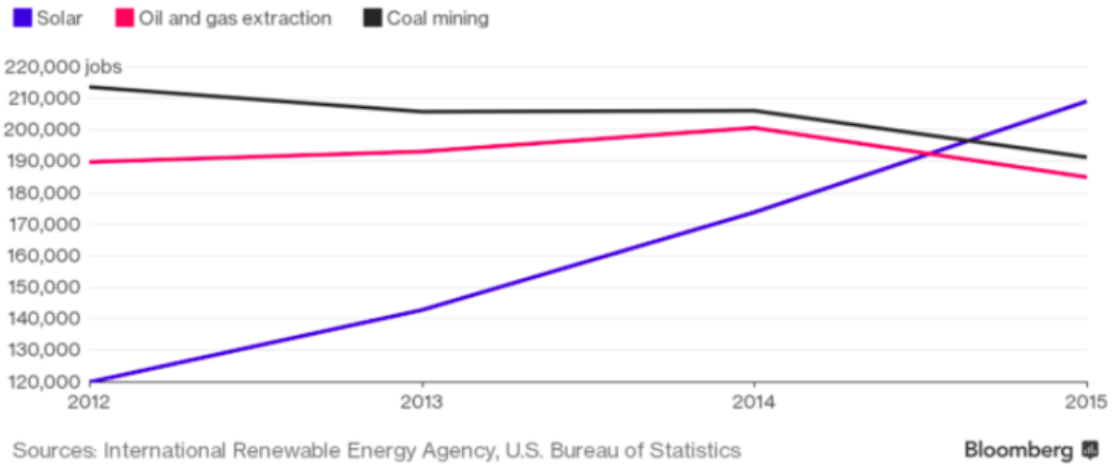
Table 2 – Employment Gains and Losses – see p. 9 for definitions of direct, indirect and induced.

Job creation per $ million of spending

Energy source	Direct jobs	Indirect jobs	Induced jobs	Total jobs
Oil & natural gas	0.8	2.9	2.3	5.2
Coal	1.9	3.0	3.9	6.9
Building retrofits	7.0	4.9	11.8	16.7
Mass transit/freight rail	11.0	4.9	17.4	22.3
Smart grid	4.3	4.6	7.9	12.5
Wind	4.6	4.9	8.4	13.3
Solar	5.4	4.4	9.3	13.7
Biomass	7.4	5.0	12.4	17.4

Source: Kats G. 2016

Figure 4 – Employment totals from 2012 – 2015



Source: Hirtenstein 2016

Figure 4 further highlights that the employment decline in coal mining and gas fossil fuels jobs is more than offset by the dramatic and accelerating increase in the creation of new jobs in the solar energy industry alone. This also supports the conclusions reached on employment so far.

In Germany, a study of energy projects (BMU, 2006) showed that of the 157,000 jobs created during the study, 71,500 were created in the energy sector itself while 81,500 new jobs were in industries supplying to the energy projects. The MISI Study (discussed on page 11) concludes similarly that the energy efficiency projects will create the most jobs.

Measuring employment gains and losses for the whole economy To gain the best measure of jobs created and lost, it is necessary to look at the entire supply and income chain related to the specific energy efficiency investments. This includes direct employment in the household or municipal projects, indirect employment in the supply chains providing the materials for the project, and induced spending caused by the follow-on gain of consumption and employment derived from the increased income/wages

and consumption of all vendors and contractors (the multiplier effect). The losses – direct, indirect and induced jobs lost – must also be measured: the displacement of workers and vendors, and the further loss of income, consumption and jobs displaced by a new investment project replacing a former product. Only a general equilibrium model of the entire economy can capture these diverse and dynamic effects which will be discussed in Section D. (Ettenson 2018 p4)

Employment The projects described in this section are employment winners-all-round and they complement the basic transition mechanism of the carbon dividend and tax. They accelerate the energy transition, lower families' future energy bills and conversion costs, and protect the populace from energy blackouts and heat waves caused by climate change. In addition, these projects will employ workers for both basic and high skill jobs. (USEEP 2018)
Both the extent of job expansion and the emphasis on construction jobs are further confirmed by the U.S. Energy and Employment Report (USEEP) 2018 Report:

> *"The report shows that the country had nearly 3.2 million Americans working in wind, solar energy efficiency, and other clean energy jobs in 2017, outnumbering fossil fuel jobs by 3 to 1. A comprehensive look at energy jobs in America showed once again that clean energy jobs – especially in energy efficiency – are the driving force behind growth in this sector. … These jobs – like installing utility scale solar energy projects, operating windmills, and manufacturing energy efficient equipment and appliances – pay more on average that the national median and are located all across the country from the coasts to rural communities and in the Rust Belt". (Ettenson 2018 p1-2)*

Though energy-efficiency projects will create a sizeable number of jobs, they will also increasingly displace workers because fewer projects will be add-ons, but rather they will replace existing products. Moving forward into the decade of the '30s new products will increasingly replace entire industries. The key downside concerns the jobs lost in the coal industry which is already losing out to increasing productivity and to the declining cost of solar and wind. As the transition takes off, these new energy projects will flourish and employ many workers in manufacturing, engineering, installing and maintenance. (Saha, D & S. Liu 2017).

In the longer run, a decade or so from now, the studies agree that innovation, and new technologies will break-up older patterns of production and create many jobs, often well-paying jobs. (Runyon 2019) The London School of Economics study concludes:

> *"In the long term, climate change policy will unleash a wave of innovation as firms reposition themselves and seek to exploit carbon opportunities. Jobs will be created in research and the development of low-carbon technologies. Over time, the results of this research will generate new investment and further job opportunities". (Fankhauser 2008)*

C. Employment Effects Outside of the Electric Power Sector

Once the National Energy Transition gains momentum based on broad political and popular support, it will be joined by other legislation and regulations which will drive the transition forward. The public sentiment, awareness of the worsening climate crisis and the rapidly rising cost of fossil fuel energy and climate disaster relief will force a reorganization of our economy in ways hard to imagine today. Here are a few possibilities.

- Municipalities will revamp public transportation using efficient and non-carbon fuels; they will alter building codes and require retrofitting to improve energy efficiency; they will innovate food systems, waste collection, pollution management; and improve rainwater control and collection as well as reduce heat-island effects.
- Manufacturing will also be reorganized in terms of reducing waste and using waste as an input in further manufacturing, the location of manufacturing will also be reviewed to accommodate energy efficiency. (Turner & Mathir 2018)
- Transportation will be revamped to lessen congestion and take into account new methods of passenger and freight movement.
- The rise of organic and sustainable farming will continue, and vertical urban farming in buildings using artificial light will prosper using less nutrients and energy and increasing labor per unit of output compared to today. (Gustin 2017)

Employment Many of the new varieties of infrastructure, retrofitting, and manufacturing will represent new construction creating jobs for varied construction workers, engineers, computer programmers and others. However, in many cases the new projects will replace existing facilities and industries; whole industries will be lost. Service sector jobs will increase wherever the projects create income and employment. The ramifications of energy transformation will be widespread and a yeasty process will ensue, undoubtedly increasing and decreasing employment in ways not foreseeable now.
Even so, it should be stressed that lurking beyond the terrain of this "energy transition employment impact study" lies the vast new and yet to be understood and explored employment future of artificial intelligence (AI), robotics, atomic and nano manufacturing, gig employment, and bioengineering. Though the carbon dividend and tax policy in the '20s will create many more jobs than it will eliminate, the future jobs picture for the '30s and beyond lies in a fog of uncertainty. In addition, an even denser fog hides the extent of climate disruption and destruction that will come in future decades from rising oceans, population migration, the collapse of regional or international ecosystems and the disruption of international trade caused by warfare and struggles over resources. The employment effects are unknown.

D. Employment Estimates Using National Economic Modeling

REMI Study: Employment Estimate using the REMI Synapse Model of the US National Economy – 2016 through 2035

The Citizens Climate Lobby provided a major service to our country in 2015 by contracting with the consultancy Regional Economic Models Incorporated to carry out an overall study of a carbon dividend and tax model commencing with a carbon tax of $10 per metric ton rising yearly by $10/ton from 2015 until 2035. This REMI study, unlike the sector estimates in Sections B and C, produces estimates of employment gains and losses for the entire economy with all the interconnections, time relationships, investments and feedback loops among wages, employment, consumption and production. (Citizens Climate Lobby 2019) (REMI, 2015) Their key findings show that:

- 2.8 million net jobs would be created over twenty years from 2016 through 2035 compared to the jobs that would have existed with no carbon tax and dividend policy (the baseline study); the growth is driven by the steady economic stimulus of the tax dividend and the production

of low carbon products and the citizen and governmental actions taken to reduce costs and improve energy efficiency. The employment study measures both income and employment gains and losses through 2035.

- Over the first 4 years this policy would create an estimated net increase of one million jobs, and over 9 years would create a net increase of two million jobs
- The avoidance of an estimated 230,000 premature deaths due to the reduction in air pollutants that accompany carbon emissions.
- A 50% reduction of emissions below 1990 levels in twenty years.

This general equilibrium analysis uses tax rates and 100% dividend return similar to the NETP.

MISI Study: A National Economic Model of the US Economy

The Management Information Services Inc. Study of 2009 commissioned by the American Solar Energy Society, (ASES, 2009) employed a national computer economic model utilizing Input-Output relationships to measure the employment effects of energy policy throughout the economy. This fourth contract of ASES with MISI was designed to estimate the net employment effects of a specific energy transition plan from 2011 through 2030. They assumed an investment and regulation policy using six investment areas: concentrating solar power, photovoltaics, wind power, bio-mass power, biofuels, and geothermal power. Assumptions included using the above measures in an aggressive manner starting in 2011. Their model demonstrated that these policies would reduce carbon emissions by "1.2 billion metric tons of carbon emissions per year by 2030." This, they alleged, would meet the international targets. Figures 5, 6 and 7 show their results for net job creation overall, and by source of energy and net jobs created by industry. (Bezdek 2009) This study, "Estimating the Jobs Impact of Tackling Climate Change" was contracted by the American Solar Energy Society with Management Systems Information Services, Inc. Principal Investigator, Roger H. Bezdek.

Table 3 – Net Costs and Jobs Resulting from the TCC initiative (ASES, 2009)

	Net Costs			Net Jobs	
	Annualized	2020	2030	2020	2030
	billion 2005 dollars			thousand FTE	
Energy Efficiency	-$107.9	-$84.8	-$17.4	3,533	3,360
Wind	$0.0	$0.3	-$0.4	149	93
Biofuels	$9.2	-$0.5	-$7.6	261	257
Biomass Power	$2.6	$3.3	$4.5	122	172
Photovoltaics	$4.7	$5.3	$16.0	105	340
Concentrating Solar	$6.6	$5.2	$2.2	156	147
Geothermal Power	$2.5	$4.0	$6.7	93	144
Total	**-$82.3**	**-$67.2**	**$4.0**	**4,419**	**4,513**

Source: American Solar Energy Society and Management Information Services, Inc. 2009.
Note: Table 3 lists the net (i.e. net of conventional) total life-cycle energy costs for energy efficiency and renewable energy deployments that occurred in the stated year. Positive means net cost compared to conventional and negative means a net savings.

Figure 2 - Energy Efficiency and Renewable Energy Jobs Created by the TCC initiative (ASES, 2009)

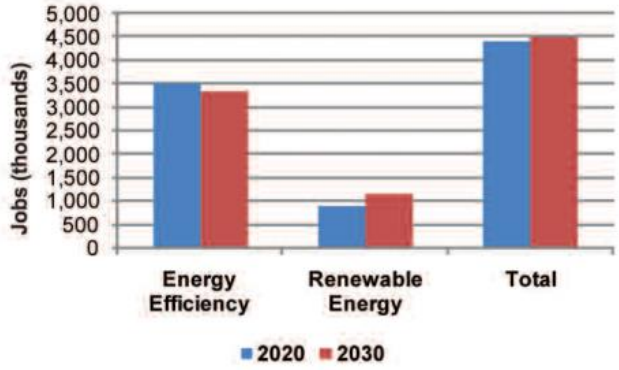


Figure 3 - Renewable Energy Jobs Created by the TCC initiative (ASES, 2009)

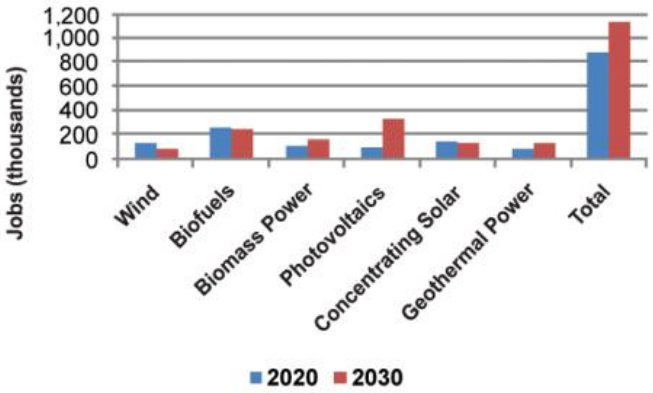
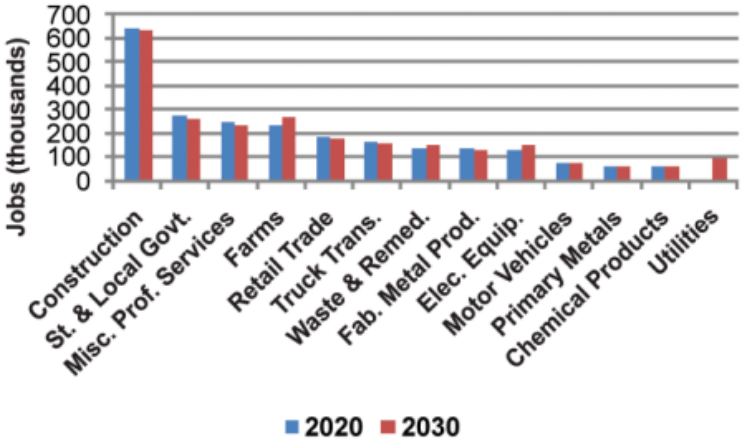


Figure 4 - Net Jobs by Industry Generated by the TCC initiative in 2020 and 2030 (ASES, 2009)



Employment Based on an aggressive climate policy of investment and regulations, the **MISI** Study estimates that "The United States can reduce carbon emissions and generate more than 4.5 million jobs by 2030," and of these 3.5 million (2011 to 2020) and 3.36 million (by 2030) net jobs would be created in energy efficiency projects, largely in construction (see Figure 5). (Bezdek 2009)

The **REMI** study which is based on a carbon dividend and tax approach estimates smaller job growth of 2.8 million net jobs over the twenty-year period to 2030.

Dr. Bezdek, head of the MISI Study, concludes using the abbreviations EE for energy efficiency projects and RE for Renewable Energy switching:

> *"EE & RE is a realistic target industry for job creation in nearly all states. EE & RE jobs require a wide range of skills, and the vast majority are standard jobs for accountants, engineers, computer analysts, clerks, factory workers, truck drivers, mechanics, etc. This rising industry will create a variety of jobs that command higher than average pay. EE & RE is more than a source of electricity, fuel, or energy savings. It is a source of jobs".*

Job Retraining Though not a part of this study, job retraining and monetary compensation to workers losing their jobs because of the transition is of utmost importance. Francesco Vona gives the following overview.

> *"In aggregate, the costs of these (job) losses are significantly smaller than the benefits, both in terms of health and probably, of labour market outcomes, but the losses are concentrated in specific areas, sectors and social groups that have been hit hard by the great recession and international competition. Compensating for the effects of climate policies on 'left behind workers' appears to be the key priority to increase the political acceptability of such policies, but the design of compensatory policies poses serious challenges." (*Vona, Francesco 2018)

Conclusion

The bustling image we saw earlier in Navarre Province in Spain turns out to be the answer to our employment question. Yes, aggressive carbon pricing measures accompanied by full payout of dividends will lift the economy and produce many net jobs. Each of the four perspectives on employment gave the same answer: jobs will be increased, and especially so in construction trades. Switching energy sources produces jobs because sustainable energy production employs more than twice the laborers per similar or same unit of output than fossil fuel production. Even taking account of individuals' increased carbon tax costs, dividends will raise the incomes of over half of our population, which will increase consumption and employment. Government transition assistance will spur manifold conversion and energy efficiency projects and employment across the country. Computer models of the economy validate the sector by sector approach projecting major job growth over losses. The NRDC report sums it up as follows: "Political leaders looking for ways to stimulate the economy should back policies that grow the clean energy sector, which also can help by reducing unemployment, lowering harmful power plant emissions and improving public health." (Ettenson 2018) In short, energy transition based on repricing carbon and rebating taxes as dividends is not only a sure way to reduce carbon emissions rapidly, but also a major growth and employment driver.

References to Employment Effects of the Energy Transition

ASES 2009 – See Bezdek below.

Bernd, Candice 2019. "Union Locals Build Support for the Green New Deal's "Just Transition', *Truthout April 6, 2019*

Bezdek, Roger H. 2009. "Estimating the Jobs Impacts of Tackling Climate Changed" Principal Investigator, Management Information Services, Inc. *American Solar Energy Society (ASES)* October 2009). https://www.eesi.org/files/ases_jobs_102209.pdf

Bloomberg New Energy Finance 2019. "Electric Vehicle Outlook 2019 Executive Summary". https://about.bnef.com/electric-vehicle-outlook/#toc-viewreport

BPA.gov 2010. "Direct Current Line still hot after 40 years" *BPA.gov.* May 29, 2010. https://www.bpa.gov/news/newsroom/Pages/Direct-current-line-still-hot-after-40-years.aspx

British Columbia Carbon Tax 2019. "British Columbia's Carbon Tax", *Government of British Columbia", September 8, 2019.* https://www2.gov.bc.ca/gov/content/environment/climate-change/planning-and-action/carbon-tax

Bureau of Labor Statistics 2019. "Occupational Outlook Handbook – Fastest Growing Occupations". https://www.bls.gov/ooh/fastest-growing.htm

California Legislative Analyst Office 2018. "Assessing California's Climate policies, An Overview". *The California Legislature's Nonpartisan Fiscal and Policy Advisor, 12 21 2018.*

Citizens Climate Lobby 2019. "The Environmental, Economic and Health Impact of *Carbon Fee and Dividend. (REMI Study) August 14, 2019*

Climate Leadership Council 2019. "Economist's Statement on Carbon Dividends" *Wall Street Journal* January 17, 2019

Cook, John 2011. "Renewable Energy Creates More Jobs than Fossil Fuels" *Software Resources, The Consensus Project, June 13, 2011*

(The) Consensus Project. "Renewable energy creates more jobs than fossil fuels" *Software Comments, The consensus Project*

Environmental Defense Fund 2018. "In Demand: Clean Energy, Sustainability and the New American Workforce" Environmental Defense Fund, January 28, 2018. http://edfclimatecorps.org/sites/edfclimatecorps.org/files/edf_in_demand_clean_energy_sustainability_and_the_new_american_workforce.pdf

Ettenson, Lara 2018. *"*Good News for Good Jobs: Clean Energy Soars*" National Resources Defense Council,* May 20, 2018. https://www.nrdc.org/experts/lara-ettenson/good-news-good-jobs-clean-energy-outpaces-fossil-fuels

Everly, Steve 2016. "Climate Activists Push Study showing 3.8 Million Lost Jobs from Renewable Energy Transition" *Energy Depth Climate and Environment January 5, 2016*

Fankhauser, Samuel, Friedel Schleier & Nicholas Stern 2008. "Climate change, innovation and jobs" London School of Economics, *Climate Policy 8 (2008) p421 – 429, May 15, 2008* page 3.

Fremstad, Anders and Mark Paul 2018. "Disrupting the Dirty Economy: A Progressive Case for a Carbon Dividend." People's Policy Project, September 2018. https://www.peoplespolicyproject.org/wp-content/uploads/2018/09/CarbonTax.pdf.

Gheorghiu, Iulia 2019. "Independent developer proposes $2.5B underground transmission line, to bring Iowa wind to PJM, MISO", *Utility Dive*, March 13th, 2019. https://www.utilitydive.com/news/independent-developer-proposes-25b-underground-transmission-line-adding/550399/

Government Offices of Sweden 2019. "Sweden's Carbon Tax," *Government Offices of Sweden.* https://www.government.se/government-policy/taxes-and-tariffs/swedens-carbon-tax/

Gustin, Georgiana 2017. "Agriculture Begins to Tackle its Role in Climate Change." Inside Climate News, January 4, 2017. https://insideclimatenews.org/news/03012017/agricultureclimate-change-paris-agreement-global-warming-drought

Hackenos, Paul 2015. "Jobs won, jobs lost – How the Energiewende is transforming the labour market", *Clean Energy; Wire*

Heutel, Garth 2018. "Do climate policies 'kill jobs'? An economist on why they don't cause massive unemployment", *The Conversation*, December 11th, 2018.

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

Hubbuch, Chris 2019. "Study: transition to renewable energy could create 162,000 jobs in Wisconsin", *Resources for the Future*, February 9, 2019

Hurlbut, David, Ella Zhou, Lori Bird, and Qin Wang 2017. "Transmission Challenges and Best Practices for Cost-Effective Renewable Energy Delivery across State and Provincial Boundaries,", *National Renewable Energy Laboratory. March 2017 Section 3.3.3., page 14.* https://www.nrel.gov/docs/fy17osti/67462.pdf

IRENA 2018. "Renewable Power Generation Costs in 2017." International Renewable Energy Agency. January 2018. https://www.irena.org/publications/2018/Jan/Renewable-powergeneration-costs-in-2017.

Jacobson, Mark, et al 2017. "100% Clean & Renewable, Wind and Water, *Joule, vol 1* September 2017, pp 108 – 121

Johansson, Bengt 2000. "Economic Instruments in Practice 1: Carbon Tax in Sweden", OECD Workshop on Innovation and the Environment, June 2000. https://www.researchgate.net/publication/242477699_Economic_Instruments_in_Practice_1_Carbon_Tax_in_Sweden

Kammen, Daniel M., Kamal Kapadia and Matthias Frip, 2006. "Putting Renewables to Work: How Many Jobs Can the Clean Energy Industry Generate?" RAEL Report, University of California, Berkley, Energy and Resource Group, Goldman School of Public Policy, page 1 overview. http://rael.berkeley.edu/old_drupal

Kats, Greg 2016. "How Many Jobs Does Clean Energy Create?", *GreenBiz,* December 5, 2016

Legislative Analyst's Office 2018. "Assessing California's Climate policies, An Overview", *The California Legislature's Fiscal and Policy Advisor;* December 21, 2018.

Murphy, Robert P. 2019. "The Carbon Tax in Sweden", Institute for Energy Research, October 9, 2019. https://www.instituteforenergyresearch.org/international-issues/the-carbon-tax-in-sweden/

National Energy Transition Plan (NETP) 2019. Wehrle & Wuebbles May 2019 https://greenleafadvisors.net/wp-content/uploads/NETP_Report_Final_053119.pdf

NREL 2012. "Renewable Energy Futures Study. vol 4, DC Transmission, p 26-2,3,4. 2012 https://www.nrel.gov/docs/fy12osti/52409-4.pdf

NREL 2018. "Interconnections Seam Study" https://www.nrel.gov/analysis/seams.html

Plumer, Brad and Nadja Popovich. 2019. "These Countries Have Prices on Carbon. Are They Working?" *New York Times* April 2, 2019. https://www.nytimes.com/interactive/2019/04/02/climate/pricing-carbon-emissions.html

OECD 2019. "Revenue from environmentally related taxes in Switzerland" *Centre for Tax Policy and Administration* 2019 https://www.oecd.org/tax/tax-policy/environmental-tax-profile-switzerland.pdf

OECD 2017. "Employment Implications of Green Growth: Linking jobs, growth, and green policies" *Organization for Economic Cooperation and Development. June 2017*

Oxford Martin School 2018. "Carbon dividend from polluters to households could win over the public." https://www.oxfordmartin.ox.ac.uk/news/201807-carbon-pricing/

REMI 2015. "The Environmental, Economic& Health Impact of Carbon Fee & Dividend" *Regional Economic Models, Inc. (REMI)* 2015

Runyon, Jennifer 2019. "IRENA: Transition to Renewable Energy May Create an Entirely Different World" *Renewable Energy World, January 11, 2019* https://www.renewableenergyworld.com/2019/01/11/irena-transition-to-renewable-energy-may-create-an-entirely-different-world/

S&P Global 2019. "The 2020 U.S. Renewable Energy Outlook", Market Intelligence, November 2019.

Saha, D. & S. Liu. "Increased automation guarantees a bleak outlook for Trump's promises to coal miners." *Brookings* January 25, 2017 https://www.brookings.edu/blog/the-avenue/2017/01/25/automation-guarantees-a-bleak-outlook-for-trumps-promises-to-coal-miners/

Sunlight, J. 2017. "All Sector Energy Roadmaps for 139 Countries" https://www.cell.com/joule/pdf/S2542-4351(17)30012-0.pdf

Turner, Lord Adair and Dr. Adjay Mathur. 2018. "Mission Possible: Reaching Net-Zero Carbon Emissions from Harder-to-Abate Sectors by Mid-Century." Energy Transitions Commission, November 2018. http://www.energy-transitions.org/mission-possible.

Vona, Francesco 2018. "Job losses and political acceptability of climate policies: why the 'job-killing' argument is so persistent and how to overturn it" *Climate Policy vol19, 2019 issue 4, pages 524-532.*

Wei, M,. S. Patadia, and D.M. Kammen 2010. "Putting renewables and energy efficiency to work: How many jobs can the clean energy industry generate in the US?" *Energy Policy* 38, 919-031 Table 2, p4.

http://rael.berkeley.edu/old_drupal/sites/default/files/WeiPatadiaKammen_CleanEnergyJobs_EPolicy2010.pdf

Zabin, Carol, Kevin Duncan & Erica Paul 2019. "Proposition 39 Job Creation & Quality, 2014 – 2018: A Report to the Citizens Oversight Board of the California Clean Energy Jobs Act, "UC Berkeley Labor Center" February 19, 2019.

Author:
Roy Wehrle, Emeritus Professor of Economics, University of Illinois at Springfield. Senior Economist at Brookings Institution and Senior Economist, Council of Economic Advisors to President Kennedy.